ONTARIO ASSESSMENT INSTRUMENT POOL

DRAFT

OAC BIOLOGY

UNIT II

ENERGY AND THE LIVING CELL

ONTARIO ASSESSMENT INSTRUMENT POOL

DRAFT

OAC BIOLOGY

UNIT II

ENERGY AND THE LIVING CELL

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DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021AaER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Aa
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Cell Membrane	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: fluid mosaic model intrinsic/extrinsic proteins

Guideline Objective

Students will be encouraged to develop an appreciation of the relationship between structure and function in cell membranes and mitochondria.

Item Focus

The student will state the biological principle of structure determining function and demonstrate this principle by relating the structure of the cellular membrane as illustrated by the fluid- mosaic model.

Item

An underlying biological principle that guides both experimentation and explanation is the principle of the relationship between *structure* and *function*.Discuss this principle with reference to the fluid-mosaic model of cellular membranes.

Response/Marking Scheme

The structure/function principle essentially says that the function performed by a biological entity is determined by the unique structure that the entity possesses. 2

A change in structure can result in a change in function. 1

The fluid-mosaic model of the cell membrane suggests that the membrane consists of a a bimolecular lipid portion with proteins scattered here and there on the surfaces (extrinsic proteins) and in some cases, proteins that can apparently move back and forth across the membrane. 2

Cholesterol molecules, attached to the outside surface of the membrane, serve in a number of capacities, one of which is to provide the membrane with structural stability. 2

Fat-soluble molecules, too large to pass through cellular pores, are known to pass through membranes. The fluid-mosaic model explains this on the basis of areas on the surface of the membrane having only hydrophilic phospholipids in contact with the cell's external aqueous environment. 2

The fat-soluble molecules could enter the cell in these regions by dissolving their way through the membrane. 2

Molecules small enough to pass through cellular pores can diffuse through the membrane. 2

Intrinsic and extrinsic proteins, combined with the process of active transport, provide specific enzymes that are required for active transport to take place. 2

The geometrical structure visualized in the fluid-mosaic model allows for the stability of cellular membranes in the presence of water. 2

Possible: 17

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021AbER.01
GUIDELINE OBJECTIVE CODE: 21Ab 21Aa 21Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, C.3, E.5, I.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: Davson-Danielli model fluid-mosaic model structure/function

Guideline Objective

Students will be encouraged to develop an appreciation of how they can use scientific models to help them visualize and understand the functions of cell organelles; and of the relationship between structure and function in cell membranes and mitochondria.

Item Focus

The students will state reasons for the greater acceptance of the fluid-mosaic model of the cell membrane as compared to the Davson- Danielli model. The students will relate the function of the membrane to its structure.

Item

Both the Davson-Danielli and the fluid-mosaic models of the structure of cellular membranes were developed using the principle of *structure* determining *function.*

A. State the similarities and differences in the structure of the two membrane models.

B. Using the principle of structure-function, explain why the fluid-mosaic model of cellular membrane structure is more widely accepted today than the Davson-Danielli model.

Response/Marking Scheme

A. In both models the membranes consist of proteins and phospholipids. 1

Both possess two layers of lipids 1

oriented with their hydrophobic ends pointing toward each other and their hydrophilic ends directed towards aqueous areas. 2

Both had proteins located outside and inside the lipid regions. 2

The Davson-Danielli model had protein "coats" covering the hydrophilic ends of the lipids; pores were bounded by proteins. 2

The fluid-mosaic model had phospholipids exposed to aqueous media inside and outside cell membrane. 1

Molecules of cholesterol are located here and there on the outside of the membrane. 1

Intrinsic proteins are found within the structure designated by the bimolecular layers of phospholipids and extrinsic proteins are located on the surfaces of the phospholipids. 2

However, large areas of the surfaces of the cellular membranes were made of phospholipids exposed to the aqueous media. 1

B. The Davson-Danielli model encountered some difficulty explaining the passage of fat-soluble molecules through the membrane 1

because these molecules are too large to pass through the pores in the membrane, and cannot pass through proteins. 1

However, the fluid-mosaic model accounts for this by assuming that the fat-soluble molecules pass through the areas in the membrane which have phospholipids exposed to the aqueous environments. 1

The fat-soluble molecules are thought to pass through the membrane by a process that is similar to fats dissolving in fats: i.e., the fat-soluble molecules get into the cell by dissolving their way through the membrane. 1

Possible: 17

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021AbER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Ab Part 1 (3.3 f,k)
UNIT NUMBER: 02	
UNIT NAME: ENERGY AND THE LIVING CELL	INSTRUMENT TYPE: ER
TOPIC: Cell Membrane	KLOPFER: A.1, A.2, A.3, F.1, H.1, I.4
CURRICULAR EMPHASIS: S.T.S.	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: membrane research medical sciences

Guideline Objective

Students will be encouraged to develop an appreciation of the relationship between structure and function in cell membranes and mitochondria.

Item Focus

The student will demonstrate an appreciation for the importance of cellular research by constructing a plausible argument for the funding of cellular membrane research.

Item

A significant amount of research money goes to the funding of work dealing with the structure and function of cellular membranes. Because there is a limited amount of money available for research, decisions must be made as to the allocation of these funds.

Construct an argument that you would make if you were trying to convince a funding agency to allocate significant amounts of research money for membrane research.

Response/Marking Scheme

A history of the field shows that this area of research has been fruitful in that many of the research questions which have been asked have yielded answers (structure of membrane). 2

In medical sciences, a number of chemicals (drugs) are known that are particularly effective against viral, bacterial, and fungal infections. However, it is often very difficult to get these chemicals through cell membranes into cells where they are needed. 2

Often, viruses and bacteria attack specific types of cells. An effective way of treating these infections would be to get specific chemicals to enter only the cells affected and not unaffected cells. 2

If the cellular membrane structure were better understood, perhaps the means by which disease-causing organisms recognize the membranes of specific types of cells could be used to get chemicals used in treating disease-causing organisms to enter only the affected cells. 2

The specificity of cellular membranes of certain types of leucocytes in terms of recognizing foreign invaders of the body is worthy of study. If the processes by which recognitions are made by cells were understood, then biologists would have some way of recognizing and isolating specific types of cells for study. 2

Possible: 10

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021SaMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Sa
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2
TOPIC: Cell Structures	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: mitochondrion organelles electron micrography (EM)	

Guideline Objective

Students will have the opportunity to develop skill in interpreting the detailed structure of cellular membranes and mitochondria from electron micrographs.

Item Focus

The student should be able to identify mitochondria in an electron micrograph of a cell.

Item

Refer to Figure 2S.1.

ELECTRON MICROGRAPH OF A CELL FROM THE BLOOD OF AN INSECT (× 15000)

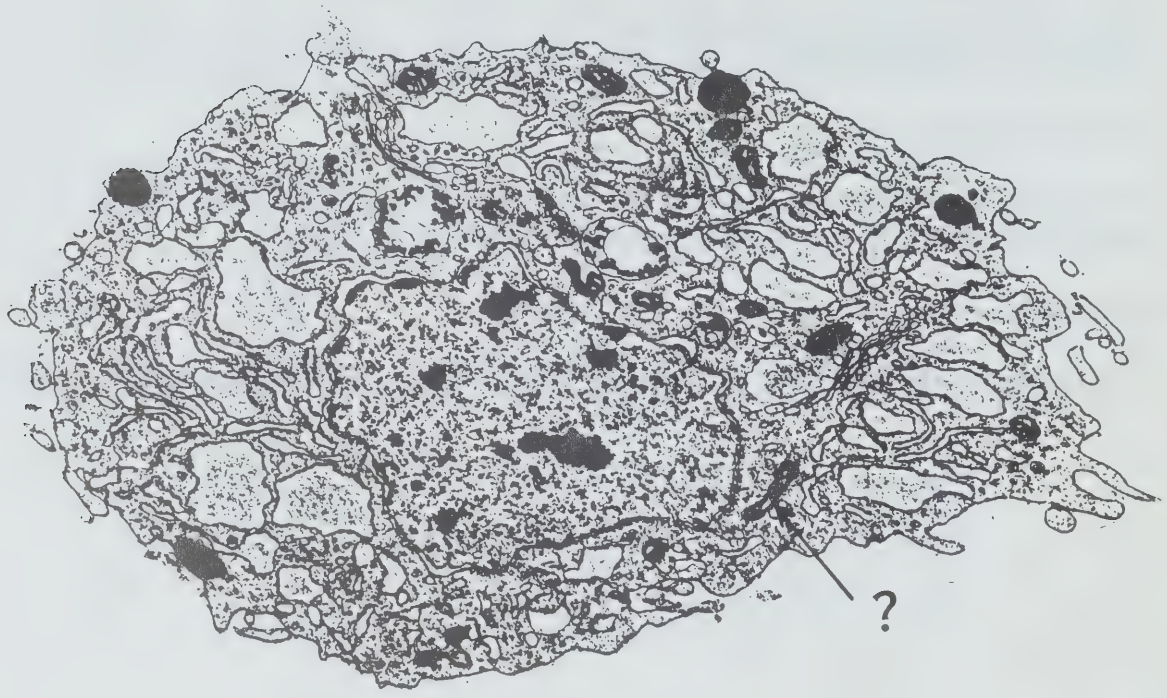


Figure 2S.1 is an electron micrograph of a cell of an insect's blood. What is the identity of the organelle indicated by the arrow?

- A. nucleus
- B. chloroplast
- C. Golgi apparatus
- D. mitochondrion
- E. lysosome

Response/Marking Scheme

Correct response: D

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Mitochondria
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021SaER.01
GUIDELINE OBJECTIVE CODE: 21Sa
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: mitochondrion organelles electron micrography (EM)

Guideline Objective

Students will have the opportunity to develop skill in interpreting the detailed structure of cellular membranes and mitochondria from electron-micrographs.

Item Focus

The student should be able to interpret the structure of a mitochondrion from an electron micrograph.

Item

Refer to Figure 2S.2.

Figure 2S.2 is an electron micrograph of some organelles in an insect's blood cell.

A. What are the large dark organelles shown?

B. What do the photographs show about the shape and structure of these organelles?

Response/Marking Scheme

A. Mitochondria	1
B. Mitochondria are variable in shape, sac-like,	2
with circular cross-section,	1
and elongated.	1
They are surrounded by a double membrane.	1
The inner membrane extends into the interior as	1
numerous shelf-like folds or cristae.	1
The clear interior implies a lower density to electrons.	1
Possible:	9
Maximum:	6

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021SbLA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Sb
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER:
TOPIC: Permeability	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: differential permeability	

Guideline Objective

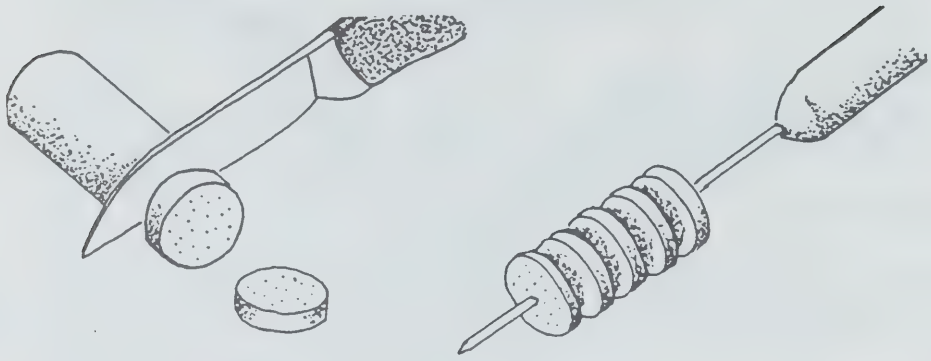
Students will have the opportunity to develop skill in designing and performing experiments to investigate the effects of environmental factors on the movement of materials through cell membranes.

Item Focus

The student should be able to interpret the results of a laboratory exercise to demonstrate the effect of temperature on the permeability of a living cell membrane.

Item

Refer to Figure 2S.3 and the table to answer this question.



A laboratory activity was carried out using sections of beet to determine the effect of temperature on the selective permeability of its cells. The red pigment found in beet is contained within its cells. The amount of pigment which leaked into the surrounding water when cells were subjected to different temperatures was used as a measure of the permeability of the cells.

The lab involved cutting cylinders of beet with a cork borer and preparing 25 discs of beet, each 3 mm thick, as shown in Figure 2S.3. The discs were then rinsed thoroughly in tap water. Next, the discs were divided into 5 sets of 5 each. One set was frozen, and the other 4 sets were placed in water baths of 20°C, 40°C, 60°C, and 80°C each for exactly one minute. The five sets were then transferred to marked test tubes each containing 5 mL of water at room temperature. After 15 min, the colour of the water in the test tubes was compared. The experimental results were as follows:

Table (Experimental Results)

Temperature	-10°C	20°C	40°C	60°C	80°C
Colour	red	pale red	pale red	red	dark red

Answer the following questions based on this activity.

1. Why was it necessary to wash the discs thoroughly at the beginning of the activity?

2. What evidence is there that the cell wall and/or the cell membrane of the cells is selectively permeable with respect to pigment?

3. What information about the selective permeability of a cell can be obtained from the test tubes marked 60°C and 80°C?

4. One hypothesis states that the cell membrane, rather than the cell wall, is selectively permeable. How do your results support this hypothesis?

5. What other factor, other than membrane selectivity, could account for the final appearance of the test tubes marked 60°C and 80°C?

6. How would you account for the final appearance of the test tube containing the frozen beet discs?

Response/Marking Scheme

1. In the process of cutting and preparing the discs, many cells would also be cut allowing the red pigment to escape. This would interfere with the results related to temperature. 2
2. If the cell membrane or cell wall were not controlling the permeability of the cell, then the anthocyanin would escape by simple diffusion. The fact that there was no significant loss of anthocyanin at temperatures of 20°C and 40°C suggests that something was controlling the permeability. 3
3. The selective permeability no longer appears to function at temperatures above 60°C. Something has broken down. 1
4. The cell wall is made up chiefly of cellulose, which is not affected by heat. The cell membrane, on the other hand, contains protein which is affected by heat. This would support the hypothesis that the cell membrane, rather than the wall is selectively permeable. 3
5. The final appearance of the test tubes marked 60°C and 80°C could have been simply as the result of physical damage to both the cell wall and membrane by causing the cells to swell and rupture. 2
6. Ice crystals formed when the beet discs were frozen would likely physically damage the cells and allow the red pigment to escape freely. 2

Possible: 13

Maximum: 13

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021SbLE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Sb
UNIT NUMBER: 02	INSTRUMENT TYPE: LE
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER:
TOPIC: Permeability	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: differential permeability lab	

Guideline Objective

Students will have the opportunity to develop skill in designing and performing experiments to investigate the effects of environmental factors on the movement of materials through cell membranes.

Item Focus

The student should be able to perform a laboratory exercise to demonstrate the effect of temperature on the permeability of a living cell membrane.

Item

Introduction

1. You have 15 min to read over this introduction and the instructions for performing the lab.

2. After reading over the method for this activity, prepare a table to record all of your observations.

3. The laboratory exercise which follows deals with the effect of temperature on the permeability of a membrane. Make use of your knowledge of membrane structure and permeability as you perform this lab.

4. To save time, hot water is available at the front of the room.

5. Leave your lab station as you found it at the end of the lab. (Marks will be given for doing this.)

6. You may write on your lab instructions.

7. At the end of the time, hand in both your lab instructions and your written report.

8. You will have 45 min in which to complete this lab and write up your report.

Problem

What effect(s) does temperature have on the permeability of the membrane of a living cell?

Materials Available

beet
5 frozen beet discs (obtained from your teacher)
cork borer
thin dowelling, 15 cm
Bunsen burner and accessories
Pyrex beaker, 250 mL
scalpel
5 test tubes
test tube rack
dissecting needle
thermometer
beaker tongs
safety goggles
small glass plate
small kitchen vegetable knife
masking tape
hot water

Safety Precautions

1. Take care when handling the scalpel, cork borer and knife. Always cut away from you.

2. Safety goggles should always be worn when using Bunsen burners.

Procedure:

1. With a small knife or scalpel, cut the top and bottom off the beet at your lab station.

2. With the cork borer cut cylinders of tissue from the beet. Carefully, push the cylinders out of the borer using the length of thin dowelling.

3. Using a scalpel, cut the cylinders of beet into discs, each approximately 3 mm thick. (Each will have the appearance of a tiny hockey puck.) You will require a total of 20 discs.

4. Place the discs in a beaker of water and rinse them thoroughly until the water in the beaker is clear.

5. With small pieces of masking tape, label the 4 test tubes as follows: F (for frozen), 20°C, 40°C, 60°C, and 80°C. Add the same amount of cold tap water, approximately 5 mL, to each of the test tubes.

6. Prepare a water bath by placing a beaker half-filled with water adjusted to a temperature of 40°C. Use hot water from the coffee urn and mix it with tap water. If necessary, heat the water with the Bunsen burner to maintain the 40°C temperature.

7. Immerse five of the beet discs in the 40°C water bath for exactly one minute. Now remove the discs from the needle and place them in the test tube marked 40°C.

8. Record any initial observations. After 15 min, gently shake the tube and record any final observations with respect to the colour of the water in the test tube.

9. Repeat Steps 6 - 8, as necessary, to obtain results from the other sets of beet discs exposed to the temperatures listed in Step 5. The frozen beet discs (which were rinsed before freezing), can be placed directly into the test tube marked F.

Observations

Temperature	Frozen	20°C	40°C	60°C	80°C
Colour					

Discussion

1. Why was it necessary to wash the discs thoroughly at the beginning of the activity?

2. From your observations, what evidence is there that the cell wall and/or the cell membrane of the cells is selectively permeable with respect to the pigment?

3. What information about the selective permeability of a cell can be obtained from the test tubes marked, 60°C and 80°C?

4. Explain your observations.

Response/Marking Scheme

Observation Table

Temperature	-10°C	20°C	40°C	60°C	80°C
Colour	red	pale red	pale red	red	dark red

Marks for observations: 5

1. In the process of cutting and preparing the discs, many cells would also be cut allowing the red pigment to escape. This would interfere with the results related to temperature. 2
2. If the cell membrane or cell wall were not controlling the permeability of the cell, then the pigment would escape by simple diffusion. The fact that there was no significant loss of pigment at temperatures of 20°C and 40°C suggests that something was controlling the permeability. 3
3. The membrane is no longer selectively permeable at temperatures above 60°C. Something has broken down. 1
4. The cell membrane contains proteins which by heat, are 1
   denatured. When the integrity of the membrane was destroyed, the pigment escaped. Heat may have destroyed the active transport mechanism that retained the pigment within the cell. 1
   The pigment might have been part of a complex with a large protein molecule, and was released upon denaturing. 1
   The final appearance of the test tubes marked 60°C and 80°C could have been simply as the result of physical damage to both the cell wall and membrane by causing the cells to swell and rupture. 2
   Ice crystals formed when the beet discs were frozen would likely physically damage the cells and allow the red pigment to escape freely. 2

Possible: 18

Maximum: 15

Teacher Notes

1. It is suggested that 60 minutes be allowed for the activity, including the writing of the report.

2. To facilitate comparing student results, use cork borers of the same diameter to cut the cylinders of beet.

3. To save class time heating water, have a large coffee urn filled with hot water, situated where the students will have easy access to it.

4. Prepare at least 1 d in advance of the class, 5 beet discs for each lab station.Thoroughly rinse the discs under running water. Each set of 5 discs should then be speared with a dissecting needle, thoroughly rinsed and placed in a separate small petri dish and frozen. The dishes should be distributed at the beginning of the activity.

5. If you wish to reduce the time required for this activity, prepare all the beet cylinders in advance of the class as in the Procedure, Steps 1 to 4.

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Nature of Science
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021SbSA.01
GUIDELINE OBJECTIVE CODE: 21Sb
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.4, C.3, C.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: controlled experiments

Guideline Objective

Students will have the opportunity to develop skill in designing and performing experiments to investigate the effects of environmental factors on the movement of materials through cell membranes.

Item Focus

The students will recognize the reasons for, and the characteristics of, controlled experiments.

Item

A. Why do scientists design controlled experiments when they are investigating such things as the effects of environmental factors on a cell membrane?

B. What are the characteristics of controlled experiments?

C. What difficulties arise in controlled experiments to study environmental effects on living organisms or their parts?

Response/Marking Scheme

A. Controlled experiments are designed to test the validity of hypotheses. 1
They attempt to eliminate the effects of variables other than the one under investigation. 1

B. Controlled experiments replicate all of the environmental factors except one. 1
Controlled experiments must be replicable. 1

C. Because environmental factors are complex, it is difficult to single out one specific factor. 1
Factors interact, so that one factor may affect another synergistically. 1

Possible: 6

Maximum: 5

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Germination
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021ScLA.01
GUIDELINE OBJECTIVE CODE: 21Sc
INSTRUMENT TYPE: LA
KLOPFER: A.1, A.2, A.3, A.10, D.3, D.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: embryo axis endosperm

Guideline Objective

Students will have the opportunity to develop skill in designing and performing experiments to investigate the catabolism of food materials in cells.

Item Focus

The student should be able to interpret experimental data and make valid generalizations.

Item

In order to investigate changes which occur during germination, corn grains of uniform size were soaked in water for 4 hours. They were planted embryo side down on moistened filter paper in a pyrex dish which was then covered and placed in a humid dark chamber at 25°C. The root emerged during the second day and the shoot emerged during the third day. Both the endosperm and embryo axis (root and shoot) were dissected away from the single cotyledon and then both were analyzed separately. The results of the analyses are expressed on the basis of a single embryo axis and of the endosperm from the same grain. The data are presented in the table below.

Changes during resumption of growth during the germination of corn.

Germination period	embryo axis		endosperm	
(h)	4	48	4	48
Dry weight (mg)	3.00	8.20	200.0	170.0
Root length (cm)	0.37	3.48	—	—
Shoot length (cm)	0.30	1.05	—	—
Water (mg)	4.20	85.60	45.0	100.0
Sugar as glucose (mg)	0.36	1.35	2.0	0.10
Total nitrogen (mg)	0.14	0.45	3.5	2.8
Insoluble protein (mg)	0.84	2.04	22.0	15.0
Total amino acids (mg)	0.05	0.54	0.05	0.3
Nucleic acids (mg)	0.07	0.16	0.07	0.03

What conclusions can be drawn from the data in the table?

Response/Marking Scheme

The increase in dry weight of the embryo is made at the expense of the dry weight of the endosperm. Therefore, the endosperm contains the stored food for growth. 2

Growth in length of the root and the shoot begin slowly, as the cells begin to absorb water; by 48 h, when the cells are thoroughly rehydrated, growth is rapid. Therefore water is needed for rapid growth. 2

As the sugar content of the embryo increases, that of the endosperm decreased. Therefore, sugar is absorbed from the endosperm to provide the energy for growth. 2

As the total nitrogen content of the embryo increases, that of the endosperm decreases. Therefore, nitrogen is absorbed from the endosperm to build nucleic acids and proteins. 2

Insoluble protein is being reduced in the endosperm as it builds up in the embryo. At the same time, more amino acids are becoming available. Therefore, insoluble proteins are being digested to make amino acids available. 2

Nucleic acids are increasing in the embryo, and decreasing in the endosperm. Therefore cell division in the embryo is building up many new cells, each with its complement of nucleic acids. 2

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Diffusion Experiment
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021SdMC.01
GUIDELINE OBJECTIVE CODE: 21Sd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: diffusion

Guideline Objective

Students will have the opportunity to develop skill in interpreting and graphing data from experiments on the movement of material through membranes and catabolism in cells.

Item Focus

The student should be able to predict the outcome of an experiment involving diffusion.

Item

A starch suspension was placed in a length of cellophane tubing and securely tied at both ends. The mass of the sac was determined, and then it was placed into iodine solution in a beaker. After an hour, you would expect that

☐ A. the sac would gain mass because of plasmolysis.

☐ B. the sac would lose mass because of osmosis.

☐ C. the sac would remain the same since equal amounts of water would enter and leave.

☐ D. the solution in the beaker would turn blue-black.

☐ E. the sac would gain in mass and its contents would turn blue-black.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Active Transport
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021SdMC.02
GUIDELINE OBJECTIVE CODE: 21Sd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10, D.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: active transport passive transport

Guideline Objective

Students will have the opportunity to develop skill in interpreting and graphing data from experiments on the movement of material through membranes and catabolism in cells.

Item Focus

The student should be able to interpret experimental evidence in terms of the model explaining transport across a membrane.

Item

Some cells were observed under a microscope as they responded to a coloured dye placed in the surrounding water. Only small amounts of dye entered living cells. A lot of dye entered and remained in any cells that were dead. The best interpretation of these observations is that cells

- [ ] A. take in dye by active transport, and then lose it by passive transport.
- [/] B. take in dye by passive transport, and remove it rapidly by active transport.
- [ ] C. take in dye by active transport, and remove it rapidly by active transport.
- [ ] D. take in dye by passive transport, and lose it by passive transport.
- [ ] E. take in the dye by diffusion, and retain it by active transport.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021SdLA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Sd
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, B.2, D.3.
TOPIC: Diffusion Experiment	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: diffusion starch test differentially permeable membrane

Guideline Objective

Students will have the opportunity to develop skill in interpreting and graphing data from experiments on the movement of material through membranes and catabolism in cells.

Item Focus

The student should be able to interpret the results of an experiment on diffusion.

Item

Refer to Figure 2S.5

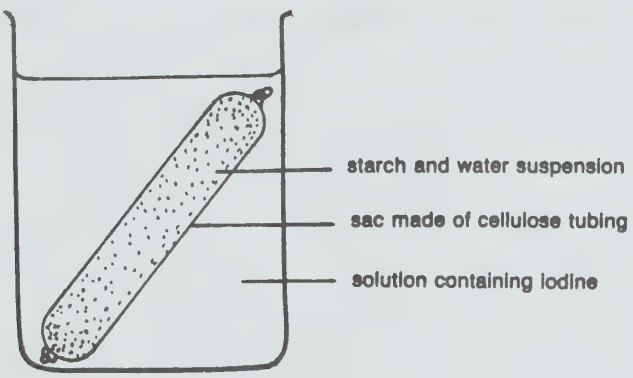


Figure 2S.5 represents an experiment in which a starch and water suspension was placed inside a sac made of cellulose tubing (differentially permeable) tied tightly at both ends. Assume that the sac does not leak. Outside the sac was water containing molecular iodine.

After 24 h the solution outside the sac had become completely colourless, and the suspension inside the sac had turned blue-black.

A. Name and define the process involved in the experiment.

B. Explain fully why the solution outside the sac became colourless.

C. Why did the starch suspension change colour?

Response/Marking Scheme

A. Diffusion: 1

The movement of molecules from a high concentration to a lower concentration. 2

B. Very few iodine molecules remained in the outside solution because most had diffused out of the solution. 1

As they diffused through the cellulose sac, they combined with the starch molecules, forming a 1

starch-iodine complex (or compound). 1

This removed them from the solution within the sac, 1

maintaining a concentration gradient of iodine from 1

the outside to the inside. Thus most of the iodine molecules diffused into the sac, preventing an equilibrium across the membrane. 1

(A few of the iodine molecules diffused out of the solution into the air, since they can always be detected by the odour above an iodine solution.) The colourless liquid outside the sac showed that starch molecules did not diffuse through the sac. 1

Starch molecules are likely larger than the pores in the cellulose. 1

C. Iodine molecules combine with starch molecules to form a starch-iodine complex, an addition compound. 1

Because this compound has a particular structure, it absorbs light and appears blue-black. 1

Possible: 13

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021SdLA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Sd
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1,A.2, A.3, A.5, D.3, D.6
TOPIC: Cellular Respiration	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: aerobic respiration control experimental technique

Guideline Objective

Students will have the opportunity to develop skill in interpreting and graphing data from experiments on the movement of material through membranes and catabolism in cells.

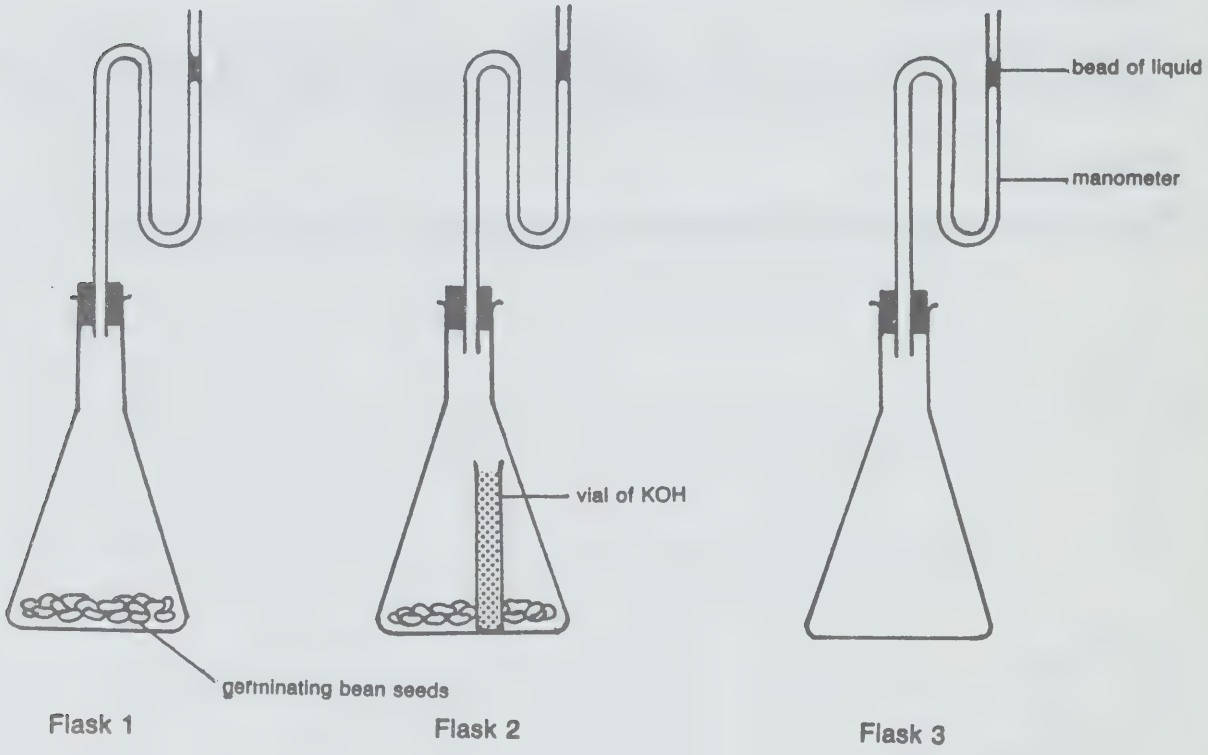
Item Focus

The student should be able to interpret experimental data in terms of aerobic respiration.

Item

The questions which follow are based on data obtained in an experiment. Equal masses of germinating bean seeds were placed into two closed flasks, as shown in Figure 2S.4. One of the flasks contains a vial of potassium hydroxide, to absorb the carbon dioxide from the air in the flask. A third flask was set up as a control and contained glass beads equal in volume to the seeds. All three flasks are equipped with manometers to measure the changes in volume of the contained gases.

GAS EXCHANGE IN GERMINATING BEANS



After 20 min, the following changes in volume were measured:

Flask 1	Flask 2	Flask 3
–10 mL	–28 mL	–3 mL

A. Explain the differences in results in the three flasks.

B From the information provided, is it possible to calculate the total oxygen consumed, or the carbon dioxide evolved?
If so, complete the calculation, and show the steps involved. If not, state what additional information would be required and why it would be required.

C. What assumptions were made by the experimenters?

Response/Marking Scheme

A. Flask 3, the control, shows any change in volume that is a direct result of environmental conditions, such as temperature or pressure. 1

Flask 2 shows any changes in the experiment that are NOT due to carbon dioxide, since this gas is absorbed by the potassium hydroxide. 2

Flask 1 shows the result of any net change in gas combined with the effects of environmental conditions. 2

B. Yes, the value of oxygen consumed or carbon dioxide evolved can be determined. 1

To obtain the volume of oxygen consumed, subtract the volume decrease in the control (Flask 3) from the volume change of the flask with potassium hydroxide, Flask 2. 2

28 mL - 3 mL = 25 mL of oxygen consumed. 2

To obtain the volume of carbon dioxide evolved, first correct the volume for Flask 1 by subtracting the effect of environmental changes (Flask 3): 2

10 mL - 3 mL = 7 mL. 1

In Flask 1, the net oxygen consumption would be the same as in Flask 2. 1

Therefore, the difference in the corrected volumes of the two flasks must be due to the volume of carbon dioxide produced: 2

25 mL - 7 mL = 18 mL of carbon dioxide evolved. 2

C. Assumptions:

The beans in the two flasks were equal in their rates of respiration. 1
The beans were at the same stage of germination. 1
All flasks were under the same conditions. 1
Potassium hydroxide absorbs all carbon dioxide. 1

Possible: 22

Maximum: 15

Quality: 2

Total: 17

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Osmosis
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021SdSA.01
GUIDELINE OBJECTIVE CODE: 21Sd
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, D.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: hypertonic hypotonic isotonic osmotic pressure

Guideline Objective

Students will have the opportunity to develop skill in interpreting and graphing data from experiments on the movement of material through membranes and catabolism in cells.

Item Focus

The student should be able to interpret experimental data, infer the nature of a solution surrounding some living cells, and use terms associated with osmosis.

Item

Strips of beet root were placed in a series of sucrose solutions of differing concentrations, and the data in the table below were obtained. Complete the table, and answer the three questions that follow.

STRIP #	INITIAL LENGTH	FINAL LENGTH	NAME FOR THE TYPE OF SOLUTION SURROUNDING STRIP
A	2.0 cm	2.3 cm	
B	2.0 cm	2.2 cm	
C	2.0 cm	2.1 cm	
D	2.0 cm	2.0 cm	
E	2.0 cm	1.9 cm	

1. If the cell sap in the strips of beet root has an osmotic pressure equal to that of a 3% sucrose solution, would the solutions surrounding strips A, B, and C contain a higher or lower percentage of sucrose?

2. What name is given to the condition of the cells in solution E at the end of the experiment?

3. What name would describe the condition of the cells in solution A at the end of the experiment?

Response/Marking Scheme

COMPLETION OF THE TABLE:

A hypotonic	1
B hypotonic	1
C hypotonic	1
D isotonic	1
E hypertonic	1
1. Lower	1
2. Plasmolyzed	1
3. Turgid	1
Total:	8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KaMC.01
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: phospholipid globular protein

Guideline Objective

Students will be expected to explain how a model for the cell membrane, such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to identify the components of a typical living membrane.

Item

Which of the following would be components of a typical membrane in a living cell?

I phospholipid bilayer
II globular proteins
III microtubules
IV a double hydrophobic phospholipid tails
V hydrophilic heads

Select one of the following responses:

☐ A. I, II, IV, and V only

☐ B. II, III, and IV only

☐ C. I, II, and IV only

☐ D. II, IV, and V only

☐ E. I, II, III, IV, and V

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KaMC.02
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: fluid mosaic model peripheral protein extrinsic protein

Guideline Objective

Students will be expected to explain how a model for the cell membrane, such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to identify evidence explained by the fluid mosaic model of the cell membrane.

Item

The current fluid mosaic model of the cell membrane was devised to account for all the following observations EXCEPT one. Which one is NOT part of the model?

- [ ] A. Integral (intrinsic) proteins are interspersed through the phospholipid bilayers.
- [ ] B. Phospholipids molecules are aligned with their fatty acid tails in the centre, and their phosphate heads towards the outside.
- [ ] C. Phospholipid bilayers are flexible and somewhat fluid.
- [ ] D. Integral (intrinsic) proteins move from place to place in the membrane.
- [ ] E. Peripheral (extrinsic) proteins move in the space between the bilayers.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KaMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Ka
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS:	

Guideline Objective

Students will be expected to explain how a model for the cell membrane, such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to identify a substance that would readily pass through a membrane.

Item

Which of the following substances would move most readily through a cell membrane?

- ☐ A. a lipophobic substance
- ☐ B. a lipophilic substance
- ☐ C. an ionized substance
- ☐ D. a protein
- ☐ E. a hydrophilic substance

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021KaMC.04
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: permeability

Guideline Objective

Students will be expected to explain how a model for the cell membrane , such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to identify the probable cause of a breakdown of the cell membrane.

Item

When slices of the roots of beets are slowly heated in water, suddenly at a specific temperature, the red pigment appears in the water. The most probable explanation is

☐ A. the pores of the membrane widen with increasing temperature.

☐ B. the living cell membrane is destroyed at the higher temperature, making it permeable.

☐ C. the permeability of membranes increases proportionally with increasing temperature.

☐ D. the high temperatures activate an enzyme system that transports pigment out of the cells.

☐ E. the pigment molecules move more rapidly at the higher temperature, passing through the membrane.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KaMC.05
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: diffusion passive transport

Guideline Objective

Students will be expected to explain how a model for the cell membrane , such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to identify molecular motion as the cause of passive transport.

Item

Many substances enter and leave cells by diffusion, a process of passive transport that is best explained in terms of

- [ ] A. random molecular or ionic motion.
- [ ] B. membrane permeases.
- [ ] C. cytoplasmic streaming.
- [ ] D. extracellular pressure gradient.
- [ ] E. phagocytosis.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KaMC.06
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: diffusion passive transport

Guideline Objective

Students will be expected to explain how a model for the cell membrane , such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to identify molecular motion as the cause of passive transport.

Item

Passive transport is the movement of materials across a cell membrane caused by

- [ ] A. carrier molecules.
- [ ] B. random molecular or ionic motion.
- [ ] C. electrical attraction.
- [ ] D. active transport.
- [ ] E. solvent pressure.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KaDL.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21DA
UNIT NUMBER: 02	INSTRUMENT TYPE: DL
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.11
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:
KEYWORDS: cell membrane	

Guideline Objective

Students will be expected to explain how a model for the cell membrane , such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to draw and label a diagram to represent the structure of a typical living membrane.

Item

Draw and label a diagram to represent the structure of a typical membrane (plasmalemma) of a living cell.

Response/Marking Scheme

Quality of the diagram	3
Labels, 1 mark each:	4

phospholipid layers extrinsic (peripheral) protein intrinsic (integral) protein channel (pore)

Possible: 7

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Communication
KEYWORDS: fluid mosaic model

INSTRUMENT CODE: B021KaDL.02
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: DL
KLOPFER: A.1, A.2, A.11, D.3, E.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

Students will be expected to explain how a model for the cell membrane , such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to explain how the fluid mosaic model accounts for phenomena associated with the cell membrane.

Item

A. With the aid of a labelled diagram, describe the fluid mosaic model of a cell membrane.

B. Use the fluid mosaic model to explain three significant observations that scientists have made about the functioning of the cell membrane.

Response/Marking Scheme

A. Diagram 4

Labels: phospholipids, integral (intrinsic) proteins, peripheral (extrinsic) proteins, pore. 4

Description: bilayered, fluid, movement of integral proteins. 3

B.

Observation	Explanation	
Ions small enough to pass through pores are often excluded.	Proteins control the movement of particles.	2
Fluorescent antibodies move in the membrane.	Proteins float about in the fluid phospholipids.	2
Membranes are closely involved with the biochemistry of the cell.	Proteins control reactions and penetrate membranes to differing degrees at different times.	2

Possible: 17

Maximum: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Membrane Structure/Function
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: experimental technique

INSTRUMENT CODE: B021KaMA.01
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: MA
KLOPFER: A.1, A.2, A.3, A.7, C.4
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

Students will be expected to explain how a model for the cell membrane, such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to state the experimental methods by which knowledge of the composition and characteristics of the cell membrane were obtained.

Item

For each of the following features of typical cell membranes, match the experimental technique by means of which the feature was discovered, by inserting the number of the appropriate technique in the blank to the left of the letter of the feature.

FEATURE	TECHNIQUE
_____A. dimension (thickness) of the membrane.	1. freeze fracture and etching
_____B. electrical potential difference across the membrane.	2. autoradiography
_____C. globular bodies in the interior of the membrane.	3. light microscopy (phase contrast)
_____D. mobility of the proteins within the membrane.	4. micro-electrode insertion/oscilloscope
_____E. pinocytosis by membranes.	5. transmission electron microscopy
_____F. water-filled pores in membranes.	6. measurement of cell surface tension
_____G. presence of proteins and lipids in membranes.	7. distortion of cells by mechanical forces
_____H. protein on the external surface of membranes.	8. chemical analysis of haemolysed cells
	9. study of penetration of solutes into cells
	10. effect of metabolic inhibitors on membrane transport

Response/Marking Scheme

(1 mark each)

A - 5, B - 4, C - 1, D - 2, E - 3, F - 9, G - 8, H - 6

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: fat-soluble molecules

INSTRUMENT CODE: B021KaSA.01
GUIDELINE OBJECTIVE CODE: 21Ka 21Sd
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, E.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

Students will be expected to explain how a model for the cell membrane, such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to interpret data from experiments to determine the properties of the cell membrane.

Item

In 1940 a biologist, J. F. Danielli, observed that fat-soluble molecules diffused through the membranes of living cells while polar molecules generally did not. What does this particular observation tell us about the possible structure of a living membrane?

Response/Marking Scheme

This observation suggests that the living membrane consists of a non-polar substance such as a lipid or a fat. (Note: This observation tells us little about the structure of the membrane, nor does it suggest, in any way, the presence of protein in the membrane.)

Possible: 2

Maximum: 2

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KaSA.03
GUIDELINE OBJECTIVE CODE: 21Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: rate of diffusion molecular properties

Guideline Objective

Students will be expected to explain how a model for the cell membrane, such as the fluid-mosaic model, accounts for experimental data relating to the structure of the membrane and the observed movement of materials through the cell membrane as a result of passive transport.

Item Focus

The student should be able to account for the movement of solutes and solvents through a selectively permeable membrane on the basis of the fluid-mosaic model.

Item

Different kinds of molecules diffuse at different rates across a living membrane but the rate of diffusion can be predicted for most molecules on the basis of molecular properties. What are three such properties?

Response/Marking Scheme

The three properties of molecules which can be used to predict the rate of diffusion across a living membrane are as follows: (any 3 are acceptable)

- the solubility of the molecule in a lipid, (compared to its solubility in water).
- the polarity of the molecule, and
- the mass of the molecule.
- the shape of the molecule.
- the distribution of charges on the molecule.

Possible: 3

Maximum: 3

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbMC.01
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2,
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: osmosis

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to identify terms associated with their definitions.

Item

For which of the following processes is it necessary to have two solutions of differing concentration separated by a selectively permeable membrane?

- [ ] A. diffusion
- [ ] B. active transport
- [ ] C. passive transport
- [ ] D. osmosis
- [ ] E. exocytosis

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: selectively permeable membrane	

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to identify a definition of selectively permeable membrane.

Item

A selectively permeable membrane in a living cell allows

I all materials to pass freely in both directions.
II materials to pass in one direction only.
III certain materials to pass in either direction, but restricts other materials.
IV certain materials to pass at certain times, but not at other times.

Which of the above statements are correct?

☐ A. I, II, and III only

☐ B. II, III, and IV only

☐ C. III and IV only

☐ D. II and IV only

☐ E. I, II, and IV only

Response/Marking Scheme

Correct response: C

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Osmosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbMC.03
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: permeability impermeable hypertonic

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to identify the nature of a solution and a membrane from a description of the behaviour of cells placed in the solution.

Item

When red blood cells were placed in a solution, they shrank and lost their normal shape. This shows that the solution must have been

- [ ] A. hypotonic, and the cell membrane is permeable to the solute.
- [ ] B. isotonic, and the cell membrane is permeable to the solute.
- [ ] C. hypertonic, and the cell membrane is permeable to the solute.
- [ ] D. hypotonic, and the cell membrane is impermeable to the solute.
- [ ] E. hypertonic, and the cell membrane is impermeable to the solute.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Osmosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbMC.04
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: isotonic

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

Same as above.

Item

Identical cylinders were cut from a living potato, and placed into distilled water and salt solutions of varying concentrations. A control cylinder was kept in potato juice. The cylinder whose turgor remained the same as in the fresh potato juice was in

- [ ] A. an isotonic solution.
- [ ] B. a hypertonic solution.
- [ ] C. a saturated solution.
- [ ] D. distilled water.
- [ ] E. a hypotonic solution.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: selectively permeable membrane structure/function

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the movement of solute and solvent particles through a selectively permeable membrane.

Item

A cell is surrounded by a solution that contains more sodium ions per unit volume than the intracellular solution. Which of the following will occur?

- ☐ A. Sodium ions will move into the cell.
- ☐ B. Sodium ions will <u>not</u> move.
- ☐ C. Potassium ions will move out of the cell.
- ☐ D. Water will move into the cell.
- ☐ E. Water will move out of the cell.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: selectively permeable membrane

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the movement of solute and solvent particles through a selectively permeable membrane.

Item

A cell is surrounded by a solution that contains more sodium ions per unit volume than the intracellular solution. The following list describes events which might take place.

I Sodium ions will move into the cell.

II Sodium ions will move out of the cell.

III Potassium ions will move out of the cell.

IV Water will move into the cell.

V Water will move out of the cell.

Which of the above will occur in this situation?

☐ A. I and IV only

☐ B. II and III only

☐ C. II and IV only

☐ D. I and III only

☐ E. II and V only

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbMC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Environment	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: membrane osmotic pressure structure/function

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the movement of water across a membrane.

Item

Dialysis tubing containing a 1% solution of sucrose is tied to form a closed sac. The sac is placed in a container of distilled water. The dialysis membrane is permeable to water, but not to sucrose. Water will move from the

- [ ] A. sucrose solution into the distilled water.
- [ ] B. distilled water into the sucrose solution until the osmotic pressure of the solution is greater than the hydrostatic pressure of the water.
- [ ] C. distilled water into the sucrose solution until the chemical activity of the water on both sides of the membrane is equal.
- [ ] D. distilled water into the sucrose solution until the membrane becomes turgid.
- [ ] E. sucrose solution into the distilled water until the pressure exerted by both solutions is equal.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Environment
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbMC.08
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: turgor osmotic pressure

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the movement of water into a leaf cell.

Item

When water entering a leaf cell in response to osmotic pressure has developed a turgor pressure equal to the osmotic pressure, then there will be

- [ ] A. an inward active transport of water.
- [ ] B. a net uptake of water.
- [ ] C. a net loss of water.
- [ ] D. no net movement of water.
- [ ] E. no movement of water.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbMC.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Osmosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: selectively permeable membrane	

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the direction of movement of solute and solvent particles through a selectively permeable membrane.

Item

The two arms of a U-tube are separated by a barrier of dialysis membrane. If the left side of the tube contains a 6% sugar solution, and the right side contains a 10% sugar solution, then

- ☐ A. sugar molecules will move from the left to the right.
- ☐ B. the level of the liquid will rise on the left side.
- ☐ C. the concentrations of each side of the membrane will become equal, but the levels of the liquid will remain unchanged.
- ☐ D. the concentration of water molecules will increase on the left.
- ☐ E. the level of the liquid will rise on the right side.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Osmosis
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021KbMC.10
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: selectively permeable membrane

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the consequences of the movement of water through a differentially permeable membrane.

Item

The mass of a bag made of differentially permeable dialysis tubing containing a 20% solution of sucrose was determined. The bag was then placed in a beaker containing an unknown liquid. Two hours later, the mass of the bag was found to be 10 g lighter. The liquid in the beaker most likely was

☐ A. distilled water.

☐ B. 10% solution of sucrose.

☐ C. 20% solution of sucrose.

☐ D. 30% solution of sucrose.

☐ E. tap water.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Environment
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbMC.11
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: isotonic solution

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the direction of movement of solute and solvent particles through a selectively permeable membrane.

Item

If an animal cell is placed in an isotonic solution,

☐ A. water will move into the cell, not out of the cell.

☐ B. water will move out of the cell, not into the cell.

☐ C. there will be no movement of water into or out of the cell.

☐ D. osmosis will take place.

☐ E. water will move equally in both directions.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbMC.12
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.10
TOPIC: Osmosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: selectively permeable membrane

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict the movement of water across a differentially permeable membrane.

Item

If a 10% sugar solution were separated from a 10% starch suspension by a differentially permeable membrane,

- ☐ A. water molecules would move equally in both directions.
- ☐ B. water molecules would move from the starch suspension into the sugar solution.
- ☐ C. water molecules would move from the sugar solution into the starch suspension.
- ☐ D. sugar molecules would move into the starch suspension and starch molecules would move into the sugar solution.
- ☐ E. nothing would move through the membrane.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Osmosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbMC.13
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: plasmolysis

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to identify the nature of a solution from the behaviour of cells placed in it.

Item

The loss of water from a plant cell, causing the cytoplasm to shrink away from the cell wall, can be brought about by placing the cell in

- [ ] A. distilled water.
- [ ] B. water close to the boiling point.
- [ ] C. an isotonic solution several degrees above normal temperature.
- [ ] D. a 10% solution of calcium chloride.
- [ ] E. a 0.5% suspension of starch.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Environment
CURRICULAR EMPHASIS:

INSTRUMENT CODE: B021KbER.01
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.6, C.2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: osmosis hypotonic

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to use the term, hypotonic, to describe a practical application of osmosis, and explain events in terms of the movement of particles through a selectively permeable membrane.

Item

A section of egg shell was removed from one end of a hen's egg, without disrupting the internal membrane. The egg was then placed in tap water for 24 h. It was then observed that the egg white and yolk were bulging through the place where the shell had been removed.

A. State the scientific adjective used to describe the osmotic pressure of tap water relative to the contents of the egg.

B. Account for the observations.

C. Predict the appearance of the egg following exposure to tap water for an additional 24 h.

Response/Marking Scheme

A. Tap water is hypotonic. 1

B. Molecules of water have a greater ability to move about in tap water than in egg material (higher chemical 1
activity) because there are fewer solute molecules in the tap water to restrain them. 1

Therefore, at any given moment, more water molecules enter the egg than leave it. 1

Since the solute molecules present in the egg material are too large to diffuse into the tap water through the intact membrane, 1
the difference in the mobility of water molecules on the two sides of the membrane cannot be altered. 1

Therefore, osmosis causes an increase in hydrostatic pressure within the egg, causing the contents to bulge outwards. 1

C. There should be no change. 1

Possible: 8

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: CELL PHYSIOLOGY	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:
KEYWORDS: isotonic	

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to define the term isotonic and give an example to illustrate its use.

Item

Define the term isotonic, and write a sentence to illustrate its use in a practical biological situation.

Response/Marking Scheme

Isotonic: a solution	1
having equal numbers of molecules or	2
ions per unit volume of solution as	1
compared to a second solution.	1
Example similar to: A physiological saline solution is isotonic with blood and lymph. In a hospital, physiological saline is used to bathe organs in preparation for transplant.	2
Possible:	7
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:

KEYWORDS: osmosis

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to define the term osmosis, and use it in a sentence to illustrate its meaning.

Item

Define osmosis, and use the word in a sentence to illustrate its meaning in the context of a living organism.

Response/Marking Scheme

Osmosis is the net movement by diffusion	2
of water	1
through a selectively permeable	1
membrane,	1
from a solution that contains more water per unit volume.	1
(OR: -for the last point, accept: from a solution that contains water at a higher chemical activity/potential)	

Example similar to:

Osmosis causes water to enter cells when they are surrounded by a hypotonic solution.	2

Possible: 8

Maximum: 5

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Environment
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbER.04
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: hypertonic hypotonic isotonic

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to describe and explain the results of the movement of water across a selectively permeable membrane.

Item

Describe and explain the results you would expect if red blood cells and onion epidermal cells were placed into solutions that were isotonic, hypotonic, and hypertonic to the cell contents.

Response/Marking Scheme

Isotonic: no net movement of water should occur in either kind of cells, since the osmotic 2

pressure of the solution and the cells is the same; no change in the appearance of the cells. 2

Hypotonic: Since the solution contains a lower concentration of solute particles than the cells, there should be a net movement of water into the cells. 2

If the difference is significant, the red blood cell will burst from the inward flow of water (hemolysis). 2

The onion cell will only take in water until it becomes turgid, then the net inward flow will stop. 2

The cellulose cell wall counteracts osmotic pressure. 1

Hypertonic: Since the solution contains a higher concentration of solute particles than the cytoplasm, the net movement of water is out of the cells. 2

This flow occurs until until the concentrations of solute are the same, or 1

in the plant cell, plasmolysis occurs. 1

The red blood cells shrivel up and cease to function. 1

Possible: 16

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Osmosis
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B021KbER.05
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.10, D.3, F.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: glucose starch

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to apply knowledge of osmosis and development to everyday life.

Item

A wise consumer uses knowledge of the "Greengrocer Test Series" to make a good choice of fruits and vegetables. The Greengrocer Test for best tasting yellow ("butter") beans requires a visual and a physical examination.

Towards the ends of their pods, the best beans are likely to be greenish rather than yellow. When flexed, the best beans will break with a slight snapping sound, rather than bend without breaking.

Account for the better taste of beans that pass the Greengrocer Test compared to those that fail it.

Response/Marking Scheme

Better tasting beans contain a substantial part of their energy reserves in the form of glucose, rather than starch	1
Therefore, choose younger (but ripe) beans, rather than fully ripened beans,	1
since sugars are converted to starch during maturation,	1
preparing the seeds for long-term survival by removing water.	1
A little green towards the tip of a yellow pod shows that ripening is not quite complete	1
so the bean should still taste sweet. After the fruit is picked, a conversion from glucose to starch begins quite quickly.	1
although the production of yellow pigment, and the loss of green chlorophyll are not so rapid.	1
Following picking, water continues to be lost from the fruit by transpiration,	1
so the degree of turgor of the fruit is a good indicator of how long and at what temperatures the beans have been kept.	1
A bean that snaps when flexed contains cells of high turgor indicating either	1
that it has been picked quite recently,	1
(so that the conversion from glucose to starch has not had time to proceed very far), or	1
that the bean has been stored at low temperatures	1
(so the enzymatic reaction converting glucose to starch has been greatly retarded).	1
Possible:	14
Maximum:	10
Quality:	2
Total:	12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbER.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.7, A.10, B.2, C.2, D.3
TOPIC: Osmosis	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: osmosis plasmolysis	

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to predict and explain the movement of materials across a living cell membrane.

Item

A scientist prepared two wet mounts of the same alga. One was exposed to a low but lethal concentration of cyanide, but the other was not. To each preparation, a concentrated solution of urea ($H_2N - CO - NH_2$) was added. Both mounts were observed through a microscope for a period of time.

The observations were the same in both preparations. At first, the interior of the cells (protoplasts) shrank and pulled away from the cell wall. This took about 1 min. Then, slowly, the cell contents expanded again, until after about 45 min the cells seemed to have resumed their original appearance.

A. Explain the observations described above.

B. What was the significance of the cyanide solution?

C. Predict what changes would be observed if sufficient table salt (NaCl) were added to the cells along with the urea to double the concentration of solute particles in the fluid bathing the algal cells. Explain your answer.

Response/Marking Scheme

A. Urea made the fluid outside the cells hypertonic	1
and so water was withdrawn from the protoplast/	1
vacuole by osmosis (plasmolysis). This was a rapid	1
response because water molecules diffuse quickly	1
through pores in the membrane.	1
Urea diffused into the cell, but	1
more slowly because its molecules are more massive	2
than water molecules, and because the urea molecules must dissolve in the membrane to enter the cells.	1
As urea built up inside the cells, their osmotic	1
pressure increased, and some water was drawn back	1
into the cells. After 45 min, urea concentrations inside and outside became equal,	1
and no further net flow of water occured.	1
B. Cyanide prevents respiration,	1
so the treated cells could not obtain energy.	1
Thus active transport could not have contributed to	1
the observations.	
C. The shrinkage would be greater because the	1
fluid bathing the cells is more hypertonic,	1
and would be faster, because of the	1
steeper concentration gradient.	1
The cell would begin to swell again, but would not recover completely since	1
the salt would remain outside the cell, because	1
the solute particles are electrically charged,	1
highly hydrated, and insoluble in lipid.	2
Possible:	25
Maximum:	15
Quality:	3
Total:	18

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbER.07
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: osmosis turgor organelles

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to describe and explain aspects of the structure and functioning of the cell membrane and the membranes of organelles.

Item

Name and describe *five* cell organelles in which the membranes are specialized to perform different functions.

Response/Marking Scheme

Any 5, such as the following, allowing 1 mark for naming, 2 marks for description, and 1 for function,

The rough endoplasmic reticulum is a network of membranes, containing specific enzyme systems for the synthesis of proteins. Ribosomes associated with the membranes assemble the proteins and push them across the membranes.

The smooth endoplasmic reticulum is a series of membranes, containing specific enzyme systems for the synthesis of non-protein secretions, such as steroid hormones.

The Golgi apparatus is composed of vesicles and stacks of flattened membranes. Enzymes in the membranes make chemical modifications to secretions, and package them for secretion. For example, they make complex sugar chains for combination into glycoproteins, or they remove part of a pro-protein to produce insulin.

Lysosomes are sacs of digestive enzymes within protective membranes. They assist in digesting ingested foreign materials taken into the cell by phagocytosis, or they recycle cellular components (mitochondria), or take part in the destruction of the cell itself, as in the resorption of the tail of a maturing tadpole.

Mitochondria are organelles made of an outer, simple membrane and an inner folded membrane which forms a large surface area (cristae). The inner membranes contain the proteins that make up the electron carrier chain, which synthesizes ATP.

Chloroplasts are organelles bounded by a double membrane, containing stacks of disks (grana) made of flattened membranes (thylakoids). Chlorophyll and associated other proteins in the thylakoids absorb the energy of light, split water molecules, and synthesize ATP and reduced NADP.

Maximum: $5 \times 4 = 20$

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021KbER.08
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.10
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: osmosis passive transport

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

Same as above.

Item

A section of egg shell was removed from one end of an egg without disrupting the internal membrane. The egg was then placed in water for 24 h. Then it was observed that the membrane and its contents bulged out.

A. Explain what had happened, and why, with reference to the type of solution outside the egg.

B. Explain whether the movement of materials is an active or passive action. What causes the movement?

Response/Marking Scheme

A. The water was *hypotonic* to the contents of the egg. 1

By osmosis, water entered the egg, creating an 1

increased turgor pressure within. 1

Osmosis moves water from where its concentration is higher to where its concentration is lower. 1

B. This is a passive action, caused by kinetic molecular action of the water molecules diffusing through the cell membrane. 2

Possible: 6

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KbLP.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kb
UNIT NUMBER: 02	INSTRUMENT TYPE: LP
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.7, B.4, C.4
TOPIC: Cell Environment	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: membrane permeability	

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to design an experiment based on the movement of particles in relation to a selectively permeable membrane.

Item

Describe how you could determine, experimentally, whether a membrane is permeable to

A. glucose, and

B. iodine.

Response/Marking Scheme

Note:
For the purposes of this answer, a membrane sac has been used to separate the solution being tested from the surrounding distilled water. A student might, however, design a comparable experiment using such things as a thistle tube and parchment paper or any other apparatus which creates as boundary between the test chemical and the surrounding distilled water. Equivalent marks should be given for any such apparatus. Diagrams should be accepted in lieu of descriptive passages.

One response is given below:

Prepare separate solutions of glucose and iodine. 1

Place these solutions in separate sacs made of the membrane to be tested, and seal the sacs. 1

Immerse the sacs in distilled water in separate 1

beakers. Test a sample of the distilled water in each beaker for the presence of the substance in the solution inside the sac. ("The control") 1

After allowing time for diffusion, remove a sample of the liquid surrounding the solution, and test the sample for the kind of molecule concerned. 2

If the membrane is permeable to the molecules inside the sacs, the tests will be positive. (See below) 2

If the membrane is impermeable by the molecules within the sacs, the tests will be negative. 2

<u>The test for glucose</u>:

Add an equal quantity of Benedict's reagent (or Clinitest) to the sample to be tested, 1

and heat in a water bath. A positive glucose test 1

is a colour change from blue to green or orange. This 1

indicates that glucose is present, and has diffused through the membrane. A negative test would be shown if the reagent failed to change in colour, indicating that the membrane was not permeable to glucose.

<u>The test for iodine:</u> Add a drop of a starch suspension to the sample to 1

be tested. If iodine is present, the whitish starch suspension will turn purple or black. If iodine is 1

not present, the starch will remain whitish. 1

A positive test would indicate that the membrane was permeable to iodine; a negative test that it was not permeable.

Possible: 14

Maximum: 10

Quality: 2

Total: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Environment
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbSA.01
GUIDELINE OBJECTIVE CODE: 21Kb
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: hypotonic hypertonic isotonic plasmolysis

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of the solute on the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to complete a chart using the names of different solutions and the effects of the solutions on plant and animal cells.

Item

Complete the chart, using the names and phrases provided: burst, cells appear unchanged, hypertonic, hypotonic, isotonic, plant cells, plasmolysed, red blood cells.

SOLUTION OUTSIDE CELL	CELL TYPE	
		cells appear normal
		cells shrivel
	cells become turgid	

Response/Marking Scheme

(1 mark for each correctly placed response)

SOLUTION OUTSIDE CELL	CELL TYPE	
	plant cells	red blood cells
isotonic	cells unchanged	(given)
hypertonic	plasmolysed	(given)
hypotonic	(given)	burst

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Environment
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KbSA.02
GUIDELINE OBJECTIVE CODE: 21Kb 21Kc
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: osmosis diffusion active transport phagocytosis pinocytosis

Guideline Objective

Students will be expected to explain the effect of temperature, pH and the type and concentration of solute in the movement of materials through cell membranes and predict the direction of particle movements across membranes.

Item Focus

The student should be able to identify processes involved in the movement of materials across cell membranes from descriptions of the processes.

Item

Given that there is

1. a higher concentration of sodium ions outside an animal cell than inside, and

2. a higher concentration of potassium ions inside an animal cell than outside, complete columns A and B in the following table.

COLUMN A	COLUMN B	
NAME OF PROCESS	ACTIVE OR PASSIVE	DESCRIPTION OF PROCESSES
1. _____	_____	More water molecules move from the extracellular fluid into the cell than out of the cell.
2. _____	_____	A white blood cell engulfs a bacterium.
3. _____	_____	Sodium ions move from the cytoplasm of the animal cell into the extracellular fluid.
4._____	_____	Potassium ions move from the extracellular fluid into the cytoplasm.
5. _____	_____	The cell membrane engulfs a large essential molecule and some water from the extracellular fluid.
6. _____	_____	Sodium ions move from the extracellular fluid into the cytoplasm.

Response/Marking Scheme

Completion of 12 spaces @ 1 mark each = 12

	COLUMN A	COLUMN B
1.	osmosis	passive
2.	phagocytosis	active
3.	active transport (or facilitated or carrier mediated transport)	active
4.	same as #3, above	active
5.	pinocytosis	active
6.	diffusion	passive

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: active transport ATP

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify the essential characteristic of active transport.

Item

Active transport across a cell membrane

- [ ] A. requires energy in the form of ATP.
- [ ] B. requires that the transported substance be soluble in the cell membrane.
- [ ] C. depends on molecular motion.
- [ ] D. requires molecular oxygen and glucose.
- [ ] E. involves the movement of water.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Active Transport	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify active transport as the process that can move ions against a concentration gradient.

Item

A system in which potassium ions moved from a solution containing a low concentration of ions into a cell with a higher concentration of the same ions would be an example of

- [ ] A. osmosis.
- [ ] B. passive transport.
- [ ] C. active transport.
- [ ] D. diffusion.
- [ ] E. pinocytosis.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Active Transport
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KcMC.03
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: concentration gradient ATP

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify the characteristics of active transport.

Item

Which of the following statements about active transport are true?

I It moves chemicals through membranes.
II It can move chemicals from a high concentration to a lower concentration.
III The cell must provide energy in the form of ATP.
IV It is usually quite selective.
V It only occurs across living membranes.

Select your response from the following:

☐ A. I, III, V only

☐ B. I, III, IV, V only.

☐ C. II, III, IV, V only.

☐ D. I, II, III, IV, and V.

☐ E. I and V only.

Response/Marking Scheme

Correct response: D

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Active Transport
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KcMC.04
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: potassium ions

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify the process of active transport from a description of an example.

Item

A system in which potassium ions moved from cytoplasm containing a low concentration of ions into a vacuole with a higher concentration of potassium ions would be an example of

- [ ] A. osmosis.
- [ ] B. passive transport.
- [ ] C. active transport.
- [ ] D. diffusion.
- [ ] E. pinocytosis.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Active transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: ATP	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify the characteristics of active transport.

Item

Which of the following statements about active transport are true?

I It involves ATP.
II It only occurs in animal cells.
III It only moves particles from a high concentration to a lower concentration.
IV It only occurs across living membranes.
V It can maintain a concentration gradient across a membrane.

Select your response from the following:

☐ A. I, II, and III only

☐ B. I, III, and IV only

☐ C. II, III, and IV only

☐ D. I, IV, and V only

☐ E. III, IV, and V only

Response/Marking Scheme

Correct response: D

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: diffusion graphical analysis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to recognize molecular movement which results from active transport.

Item

Refer to Figure 2K.1.

UPTAKE OF IONS BY PLANT TISSUE

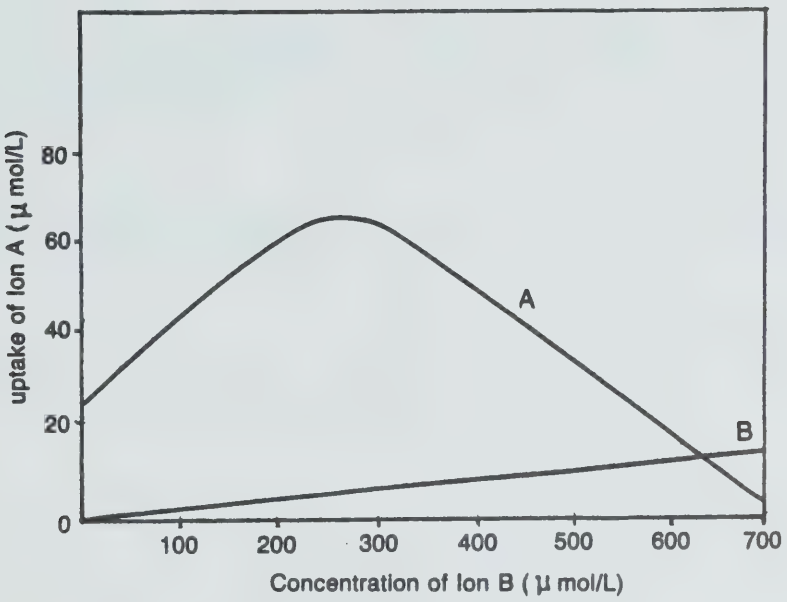


Figure 2K.1 shows the results of an experiment involving the uptake of two ions into living plant tissue. Uniform discs of carrot tissue were placed in a solution of ion A, and the amount of ion B was increased during several trials. The amounts of both ions absorbed were measured in each trial. Which of the following provides a possible explanation for the results?

☐ A. Both A and B appear to move into the cell by diffusion.

☐ B. A appears to move in by active transport, B by diffusion.

☐ C. B appears to move in by active transport, A by diffusion.

☐ D. A appears to move into the cell by active transport, but B does not appear to move either by diffusion or by active transport.

☐ E. B appears to be diffusion, but A does not appear to move either by diffusion or by active transport.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: graphical analysis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret data from graphs.

Item

Refer to Figure 2K.2.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

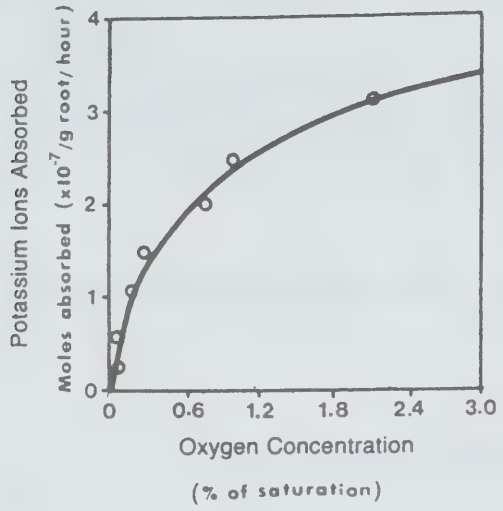


Figure 2K.2 shows the results of an experiment in which the uptake of potassium ions into living plant tissue is measured at increasing oxygen concentrations.

From the data provided, it appears that

☐ A. the entry of ions into the cell is independent of oxygen.

☐ B. the oxygen serves as a carrier molecule for the ion.

☐ C. the oxygen binds with an inhibitor, allowing the ion to diffuse into the cells.

☐ D. the ion requires some metabolic activity to move into the cell.

☐ E. the ion enters the cell by diffusion.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: graphical analysis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret data from graphs.

Item

Refer to Figure 2K.2.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

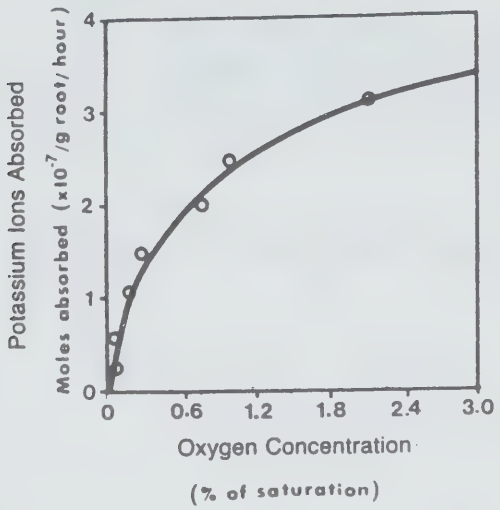


Figure 2K.2 shows the results of an experiment in which the uptake of a particular ion into living plant tissue at increasing oxygen concentrations is measured.

From the data provided, it appears that the movement of the ion into the cells is the result of

- ☐ A. simple diffusion.
- ☐ B. active transport.
- ☐ C. osmosis.
- ☐ D. diffusion at low oxygen concentrations, active transport at high.
- ☐ E. endocytosis.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.3
TOPIC: Active Transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: active transport ion uptake	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret a graph of the movement of ions by active transport.

Item

Refer to Figure 2K.4.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

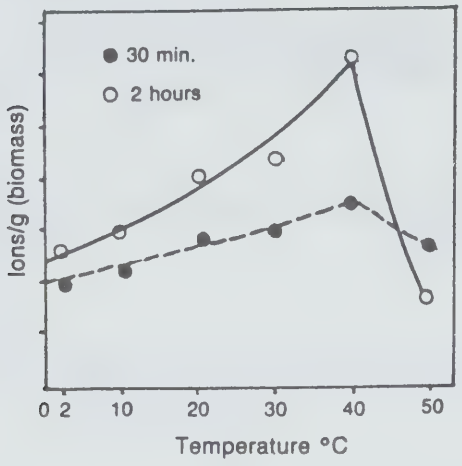


Figure 2K.4 shows the results of an experiment in which the uptake of potassium ions into living plant tissue was measured. This was carried out over a range of increasing temperatures. These measurements were made after 30 minutes and again after 2 hours. From the data presented in Figure 2K.4, the uptake of potassium appears to be carried out by

- A. diffusion.
- B. osmosis.
- C. active transport.
- D. transpiration.
- E. translocation.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: diffusion passive transport	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify molecular motion as a cause of passive transport.

Item

Many substances enter and leave cells by diffusion, a process of passive transport that is best explained in terms of

- [ ] A. random molecular or ionic motion.
- [ ] B. membrane permeases.
- [ ] C. cytoplasmic streaming.
- [ ] D. extracellular pressure gradient.
- [ ] E. phagocytosis.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcMC.11
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.11
TOPIC: Active Transport	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: pinocytosis

Guideline Objective

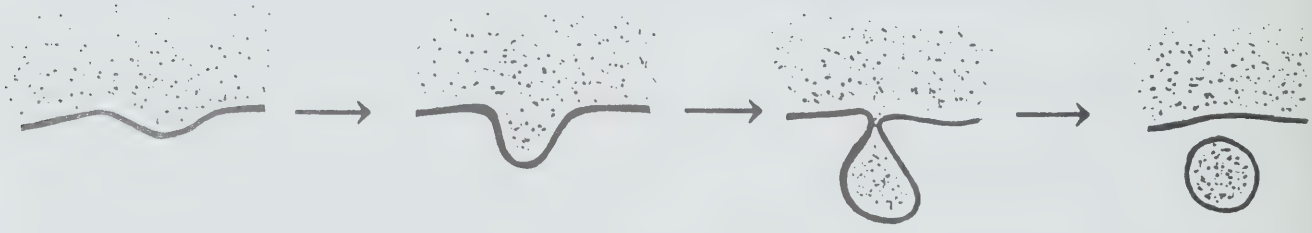
Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify a diagrammatic representation of the process of pinocytosis.

Item

Refer to Figure 2K.5.



If the steps in Figure 2K.5 represent a sequence from left to right, what process is occurring in the cell?

- ☐ A. phagocytosis
- ☐ B. pinocytosis
- ☐ C. cyclosis
- ☐ D. exocytosis
- ☐ E. osmosis

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KcMC.12
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: phagocytosis

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to identify aspects of the definition of phagocytosis.

Item

The process of phagocytosis involves the passage of

- [ ] A. solid wastes out of the cell.
- [ ] B. liquid wastes out of the cell.
- [ ] C. water into the cell.
- [ ] D. solid particles into the cell.
- [ ] E. ions of solutes into the cell.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.9, E.3
TOPIC: Active Transport Model	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:
KEYWORDS: concentration gradient	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to use a scientific model to account for the apparent characteristics of active transport (e.g., movement of solute particles against a concentration gradient).

Item

With the aid of a scientific model (such as the sodium pump model), explain how sodium and potassium ions can cross a living membrane against a concentration gradient. Use a diagram to supplement your answer.

Response/Marking Scheme

The sodium pump model is but one model used to attempt to explain how sodium and potassium ions cross a living membrane against a concentration gradient. The steps in this model can be listed as follows:

a. a carrier protein attaches to a sodium ion 2
on the inside surface of the cell membrane. 1
b. the carrier moves through the cell membrane 1
and deposits the sodium ion on the outside 1
of the cell membrane.

OR any other current acceptable model which describes the characteristics of the carrier model.

c. The above step requires the presence of ATP 1
since energy is required for this to take place. 1
d. The protein carrier now picks up a potassium 1
ion and carries it from the outside, across 1
the cell membrane to the inner surface of the 1
membrane.

As a consequence of the above steps being repeated again and again, there would be a higher concentration of 1
sodium ions outside the cell membrane and a higher 1
concentration of potassium ions inside the cell. If 2
simple diffusion were to take place, a point would be reached where there would the same concentration of sodium ions inside and outside of the cell. The same would apply to the potassium ion, with similar concentration inside and outside the membrane. (The concentration of sodium and potassium ions, however, would not necessarily be the same.)

Diagram

A diagram labelled: 2

Possible: 16

Maximum: 12

Quality: 3

Total: 15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Active Transport
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KcER.02
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: passive transport

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to compare active and passive transport in terms of the source of the energy required for each.

Item

A. What is the single essential difference between passive and active transport in a living cell?

B. Compare the two kinds of transport with respect to this difference.

Response/Marking Scheme

A. The difference between passive and active transport pertains to the source of energy 1
required to drive the processes.

B. In the case of passive transport, the energy comes from the thermal energy of the cell's 1
environment. (If there is a greater concentration of an ion or molecule, there will be greater thermal energy. Thus, in passive transport, there is a movement of a chemical from a higher to a lower concentration.) Active transport, 1
however, requires the expenditure of cell energy 1
reserves, usually involving ATP. 1

Possible: 5

Maximum: 5

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc 21Aa 21Ab 21Kd
UNIT NUMBER: 02	
UNIT NAME: ENERGY AND THE LIVING CELL	INSTRUMENT TYPE: ER
TOPIC: Cell Membranes	KLOPFER: A.1, A.2, A.3, A.9
CURRICULAR EMPHASIS: Nature of Science	DIFFICULTY LEVEL: H
	TIME ALLOCATION:
KEYWORDS: active transport	

Guideline Objective

Students will be encouraged to develop an appreciation of the relationship between structure and function in cell membranes and mitochondria.

Item Focus

The student should be able to use a structural model of the cell membrane and a physiological model of active transport and integrate them so as to demonstrate how observations apparently contrary to the second law of thermodynamics can be explained.

Item

The ability of cell membranes to perform active transport (that is, to have solute particles enter cells apparently moving from low to high concentration) is dependent on a supply of ATP. Using a model of active transport, explain the apparent movement of solute particles from low to high concentration, showing how ATP is involved. In your discussion, describe how the membrane is involved in this process.

Response/Marking Scheme

According to the second law of thermodynamics, solute particles cannot move from an area of low concentration to one of high concentration. 1

Thus a mechanism must be invoked which is in accordance with the law. The mechanism must employ diffusion as the root explanation. 1

One such model uses the idea of a carrier molecule found in the 1

cytoplasm of a cell, which is too large to leave through the pores 1

in the cellular membrane. It is postulated that the carrier 1

molecule combines with solute particles that are just inside the cellular membrane to reduce the concentration of the solute particles to virtually zero. 1

This synthesis reaction requires energy which is supplied by ATP. 1

Also, the fluid-mosaic model suggests that the enzyme required for this synthesis is embedded in the membrane. 1

In spite of the fact that the concentration of the solute may be very low outside the cell, it is still higher than the 1

concentration of the free solute particles inside the cell. 1

Therefore, the solute particles diffuse across the cellular membrane 1

in accordance with the second law of thermodynamics. 1

Possible: 12

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcLA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: ion uptake graphical analysis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret a graph of data from an experiment on active transport.

Item

Refer to Figure 2K.6.

UPTAKE OF IONS BY PLANT TISSUE

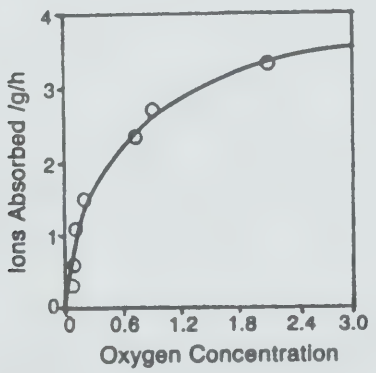


Figure 2K.6 shows the results of an experiment involving the uptake of a particular ion into living plant tissue at increasing oxygen concentration. From the information provided on the graph, what mechanism would explain the movement of the ion into the root?

Response/Marking Scheme

Since the rate of uptake increases with increasing oxygen, the movement must be due to some metabolic activity. 1

This suggests the mechanism of active transport. 1

Possible: 2

Maximum: 2

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcLA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: cell membrane graphical analysis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret a graph of data for experiments on active transport.

Item

Refer to Figure 2K.4.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

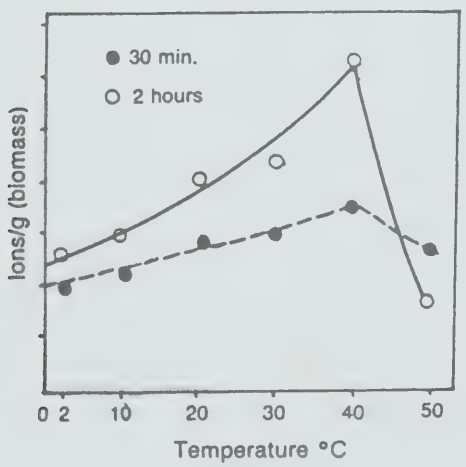


Figure 2K.4 shows the results of an experiment in which the uptake of potassium ions into living plant tissue was measured. This was carried out over range of increasing temperatures. These measurements were made after 30 min and again after 2 h, using different samples of the same tissue.

A. What do the data show? What mechanism might account for the movement involved?

B. Suggest an experiment to give further support to your explanation.

Response/Marking Scheme

A. Since both lines on the graph show an increase in ion uptake with increasing temperature to around 40°C, then decrease dramatically, it would 1

appear that the ion is taken in by active transport. The fact that the decrease in uptake begins at the same temperature gives support to this belief. 1

B. To further support the hypothesis that active transport is involved, the experiment could also be tried with tissue which is dead or with tissue influenced by various enzyme inactivators. 1

If active transport is responsible for the movement of the ion into the tissue, these conditions should decrease or stop the uptake of the ion. 1

Possible: 5

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcLA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: cell membrane graphical analysis

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret a graph of data for experiments on active transport.

Item

Refer to Figure 2K.4.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

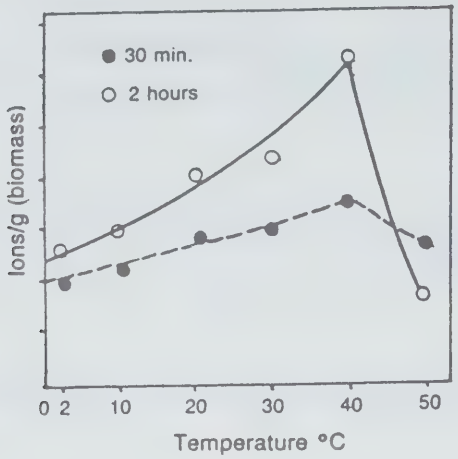


Figure 2K.4 shows the results of an experiment in which the uptake of potassium ions into living plant tissue was measured. This was carried out over a range of increasing temperatures. These measurements were made on different samples of the same tissue after 30 min and again after 2 hours.

A. Why is there a difference between the curve for 30 min and that for 2 h?

B. Explain the reason for the increasing difference between the two lines from 2°C and 40°C.

C. Why do both curves experience a drop at around 40°C?

Response/Marking Scheme

A. The two lines are different because the longer the tissues are allowed to take up the ion, the more ion appears in the tissue. 1

B. The reason for the increasing difference at 2°C and 40°C is that with increasing temperature, the enzymes involved with the movement of the ion into the tissue increase their activity. 2

As temperature increases, the kinetic molecular motion of the ions increase. 1

C. Both lines show a drop in activity at 40°C, indicating a decrease in enzyme activity due to a denaturation of the enzymes involved with the active transport of the ions into the tissue. 1

Possible: 5

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcLA.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.10
TOPIC: Active Transport.	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: cell membrane graphical analysis

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret a graph of data for experiments on active transport.

Item

Refer to Figure 2K.9.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

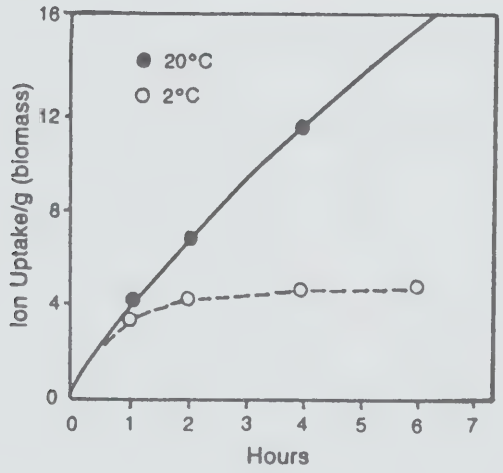


Figure 2K.9 shows the results of an experiment in which the uptake of a particular ion into living plant tissue was measured over time. This was carried out at 2°C and at 20°C.

A. Explain the difference in the slopes of the two lines.

B. What process(es) might be involved in the uptake of this ion?

Response/Marking Scheme

A. With increasing time, the difference between the two temperatures becomes more apparent. 1

The activity at 20°C continues to increase over the time period of the experiment. 1

Also, between 1 and 3 hours, the tissue at 2°C has attained its maximum rate, so that its graph shows a plateau. 1

B. From the information provided on the graphs, the uptake could be the result of either simple diffusion or active transport. 1

Possible: 4

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcLA.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: LA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8, A.10, D.1, D.10
TOPIC: Active Transport	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: cell membrane graphical analysis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to interpret a graph showing data from experiments on active transport and diffusion.

Item

Refer to Figure 2K.9.

UPTAKE OF POTASSIUM IONS BY PLANT TISSUE

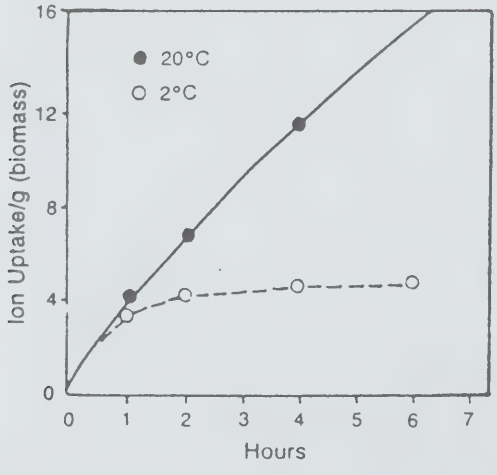


Figure 2K.9 shows the results of an experiment in which the uptake of a particular ion into living plant tissue was measured over time. This was carried out at 2°C and at 20°C.

A. From the data provided, describe any mechanism that would explain the uptake occurring.

B. What further experiment could be carried out to give support to your answer for A?

Response/Marking Scheme

A. From the information on the graphs, it would appear that the uptake of the ions involved is due to either simple diffusion or active transport. 2

The fact that activity increases with increasing temperature would support both of these types of movement. 1

B. To further determine the type of movement occurring, experiments which will effect metabolic activity should be carried out. 1

If these affect the uptake of the ions, then the movement is due to active transport. 1

The type of experiments that could be performed could involve a higher temperature (in excess of 40°C) or any chemical which would cause a denaturation of enzymes or radiation. This would kill the cell while leaving it intact. 1

Possible: 6

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Active Transport
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KcSA.01
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: concentration gradient

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to state the characteristics of active transport.

Item

State two important characteristics of active transport.

Response/Marking Scheme

Two important characteristics of active transport are as follows: (any two of)

1. It enables the movement of dissolved molecules against a concentration gradient (from low to high concentration).
2. It requires the input of cell energy reserves, usually in the form of ATP.
3. It allows transport to be selective.
4. It involves protein embedded in the membrane.

Any 2 points (×2), Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Active Transport
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021KcSA.02
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.10, H.1, I.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: cell membrane

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

Same as above.

Item

In 1900, Pfeffer, a plant physiologist, claimed; ". . . the nature of plasma is such as to render it possible that a substance may combine chemically with the plasmatic elements thus being transmitted internally and then set free again." ["Plasma" in Pfeffer's quotation means cytoplasm.]

In what ways does our current model of active transport support Pfeffer's claim?

Response/Marking Scheme

Cellular movement that results from active transport is	1
believed to involve some combining, or interaction, of the material to be moved	
and some cellular component.	1
It is thought that some protein molecules of the cell membrane	1
can become carriers, combining with ions or molecules outside the cell,	1
transporting them across the cell membrane and releasing them inside the cell.	1
The "combining" or interaction is believed to occur with the membrane of the	
cell.	1
In part, Pfeffer was correct in hypothesizing that some interaction was taking	
place for the movement to occur into a cell, but his limited knowledge did not	
allow him to locate the site.	1
Possible:	7
Maximum:	5

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cell Membrane
CURRICULAR EMPHASIS: Communication

INSTRUMENT CODE: B021KcSA.03
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: pinocytosis

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to define pinocytosis, and state its importance.

Item

A. Define pinocytosis.

B. How is this process used in cell functioning?

Response/Marking Scheme

A. Pinocytosis is the process whereby the cell membrane forms a pouch and brings into the cell water and dissolved materials. 2

B. The process is important to the cell in that it can bring in larger quantities of water and solutes than may be able to enter through pores in the membrane by osmosis and diffusion. 2

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KcSA.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kc
UNIT NUMBER: 02	INSTRUMENT TYPE: SA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cell Membrane	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Communications	TIME ALLOCATION:
KEYWORDS: phagocytosis	

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to define phagocytosis, and state its importance.

Item

A. Define phagocytosis.

B. Give a practical example of phagocytosis. How is this process used in cell functioning?

Response/Marking Scheme

A. Phagocytosis is the process in which the cell 3
takes in solid particles by surrounding them and engulfing them. 2

B. The importance of phagocytosis is that certain cells can engulf foreign material, such as bacteria, and thus resist disease. Other cells use the process as a way of obtaining food for digestion in vacuoles. 2

Possible: 4

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Phagocytosis/Pinocytosis
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: phagocytosis pinocytosis

INSTRUMENT CODE: B021KcSA.05
GUIDELINE OBJECTIVE CODE: 21Kc
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

Students will be expected to define *active transport* and use a current theory to explain observations from experimental work.

Item Focus

The student should be able to compare and contrast pinocytosis and phagocytosis.

Item

A. State four similarities between pinocytosis and phagocytosis.

B. How do the processes differ with respect to the size of the vacuole formed, and the size of the particles involved?

Response/Marking Scheme

Any four of the following:

A.	Both are active processes, requiring cellular energy.	1
	Both are inpocketing movements of the cell membrane	1
	(the result of the contraction of acin filaments)	1
	by which materials are engulfed into the cell.	1
	Both take in more than a single molecule at a time.	1
	Both result in a fluid-filled vacuole within the cell.	1

B.

Differences:	Pinocytosis	Phagocytosis	
size of vacuole	smaller	larger	1
particles	visible through a microscope	molecular-sized	1

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd 21Kh
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: fermentation laws of thermodynamics free energy entropy

Guideline Objective

Students will be expected to describe in general terms how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify aspects of the laws of thermodynamics that account for a specific biochemical reaction.

Item

In the process of fermentation, glucose is broken down into carbon dioxide and alcohol, with the evolution of some energy. With respect to this process, it can also be said that,

- [ ] A. entropy is increasing as the reaction takes place.
- [ ] B. the free energy of the system is increasing.
- [ ] C. entropy is being converted into free energy.
- [ ] D. the reaction violates the second law of thermodynamics.
- [ ] E. the released energy is eventually used to produce more glucose.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3.
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: free energy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the meaning of 'free energy'.

Item

'Free energy' is

- ☐ A. energy which is released in every chemical reaction.
- ☐ B. energy that can do useful work.
- ☐ C. the total energy involved in a chemical reaction.
- ☐ D. energy released during endergonic reactions.
- ☐ E. heat energy.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: entropy free energy	

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the relationship between free energy and entropy.

Item

The second law of thermodynamics states that as entropy increases, free energy

- ☐ A. is released as heat energy.
- ☐ B. varies inversely with the absolute temperature.
- ☐ C. depends on the chemical reaction involved.
- ☐ D. decreases.
- ☐ E. remains constant.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: catalysis

INSTRUMENT CODE: B021KdMC.06
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the characteristic feature of chemical reactions that accounts for why they occur in terms of the laws of thermodynamics.

Item

Whether catalyzed or not, all chemical reactions proceed

☐ A. in the direction that forms smaller molecules.

☐ B. in the direction that forms larger molecules.

☐ C. if ATP is a product.

☐ D. if energy-poor reactants are involved.

☐ E. in the direction that consumes available energy.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdMC.07
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: enzyme activation energy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the role of an enzyme in a biochemical reaction.

Item

The role of enzymes in biochemical reactions is to

- [ ] A. remove electrons from the reactants.
- [ ] B. add electrons to the reactants.
- [ ] C. lower the activation energy of the reactants.
- [ ] D. speed the motion of the reactants.
- [ ] E. slow the motion of the reactants.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdMC.08
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: enzyme

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the property of a biochemical reaction that makes it possible to proceed.

Item

The rapid release of energy from glucose without enzymes would

- [ ] A. occur only at high temperatures.
- [ ] B. release more energy than a reaction using enzymes.
- [ ] C. release less energy than a reaction using enzymes.
- [ ] D. require an input of water molecules.
- [ ] E. not be possible under any circumstances.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdMC.09
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5, A.8, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: entropy free energy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify a consequence of the second law of thermodynamics.

Item

The second law of thermodynamics states that entropy is always increasing within a closed system. Expressed in another way, within the system,

- [ ] A. there is an increase in free energy.
- [ ] B. there is a decrease in randomness.
- [ ] C. energy is being captured for future use.
- [ ] D. there is an increase in disorder.
- [ ] E. there is an increase in potential energy.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdMC.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: entropy enthalpy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to use thermodynamics to identify the likelihood that a chemical reaction will take place spontaneously.

Item

A chemical reaction will occur spontaneously if

- ☐ A. change in entropy equals change in enthalpy.
- ☐ B. entropy increases and enthalpy decreases.
- ☐ C. entropy decreases and enthalpy increases.
- ☐ D. both entropy and enthalpy decrease.
- ☐ E. both entropy and enthalpy increase.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdMC.11
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: MC
KLOPFER: A.2, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: entropy free energy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the energy relationships involved in the second law of thermodynamics.

Item

The second law of thermodynamics states that as entropy increases, free energy

- [ ] A. is released as heat energy.
- [ ] B. varies inversely with the absolute temperature.
- [ ] C. depends on the chemical reaction involved.
- [ ] D. decreases.
- [ ] E. remains constant.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdMC.12
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: chemical energy cellular respiration

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to account for the various steps in the glycolytic pathway and Krebs cycle in terms of the Laws of Thermodynamics.

Item

The following molecules occur at different stages of the release of energy during cellular respiration:

I acetyl co-enzyme A

II carbon dioxide

III glucose

IV glyceraldehyde

V pyruvic acid

In which of the following are the above molecules arranged in order from the greatest to the least chemical energy?

- [ ] A. IV, III, II, I, V
- [ ] B. III, I, V, IV, II
- [ ] C. III, IV, I, V, II
- [ ] D. III, IV, V, I, II
- [ ] E. II, I, V, IV, III

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdMC.13
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Energy Transformations	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: laws of thermodynamics chemical reaction

Guideline Objective

The student will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify one of the major functions of the second law of thermodynamics.

Item

The second law of thermodynamics is useful to biochemists because it

- ☐ A. helps to predict products of chemical reactions.
- ☐ B. allows for the determination of the molecular weights of products.
- ☐ C. justifies the balancing of chemical equations.
- ☐ D. allows prediction whether a particular chemical reaction may theoretically occur.
- ☐ E. is the basis for the determination of activation energies.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdEE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: EE
UNIT NAME: Energy and the Living Cell	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: entropy enthalpy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

Same as above.

Item

Discuss the significance of the laws of thermodynamics in understanding the characteristics of living organisms.

Response/Marking Scheme

Laws of thermodynamics indicate that large molecules should break up into smaller molecules,	1
but organisms are composed of macromolecules.	1
Laws of thermodynamics indicate that high energy molecules will react, converting their energy to heat,	1
but organisms maintain molecules of great potential (free) energy.	1
Laws of thermodynamics indicate that highly ordered arrays of molecules will increase in entropy (assume a more random arrangement),	1
but organisms maintain highly ordered arrangements,	1
as in membranes and organelles.	1
Thus, in terms of thermodynamics, life is a highly unlikely phenomenon,	1
maintained only with constant consumption of energy.	1
This requires a system of storing/releasing energy.	1
Also, molecules that are degraded must be replaced,	1
requiring a source of component "building blocks".	1
Information on how to construct replacements must be kept: this is the function of DNA.	2
Laws of thermodynamics indicate that reactions will occur, but not how quickly,	1
enzymes are needed to accelerate some reactions	2
that are thermodynamically probable.	1
Possible:	18
Quality:	3
Maximum:	15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdER.01
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.8, A.10
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: free energy entropy

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to state the first and second laws of thermodynamics, and use the laws to explain a specific biochemical reaction.

Item

The following is the net equation for the anaerobic process of fermentation:

$$\underset{\text{glucose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{alcohol}}{2C_2H_6O} + 2CO_2 + \text{Energy}$$

A. State the first and second laws of thermodynamics.

B. Describe and explain in detail what is occurring during fermentation in terms of the first and second laws of thermodynamics.

Response/Marking Scheme

A. The first law of thermodynamics states that energy can neither be created nor destroyed. 2

The second law of thermodynamics states that entropy always increases in a closed system. 2

Possible: 4

Maximum: 4

B. It can be seen from the net equation for fermentation that energy is a product of the set of reactions. However, the first law of thermodynamics states that energy can be neither created nor destroyed. As such, assuming a closed system, the energy must have been 1

derived from something within the system. 1

It appears that glucose is the source of this energy. 1

The second law of thermodynamics states that in a closed system entropy increases. The glucose molecule is, in fact, a highly ordered molecule, much more so than 1

either the ethanol or the carbon dioxide products. This is consistent with the second law. Thus the reaction proceeds forward because the alcohol and carbon dioxide have a lower level of organization and free energy (available to 2

perform work) than does the glucose. If this were not the case the reaction would not occur. Some of the energy 1

which appears as a product on the resultant side of the equation is trapped 1

and used to synthesize ATP. If the energy is not trapped 1

it disperses throughout the system randomly, thus again, resulting in a lower free energy state, as suggested 1

by the second law of thermodynamics. Note that there is still some available energy in the system, trapped in the alcohol. Without the addition of oxygen, 1

however, this energy is not available to the organism. 1

Possible: 11

Quality: 1

Maximum: 9

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Communication

INSTRUMENT CODE: B021KdER.02
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: cellular respiration ecosystem

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to discuss the significance of respiration to the biosphere.

Item

A. Define cellular respiration.

B. Discuss the significance of respiration to the ecosystem.

Response/Marking Scheme

A. Respiration is the metabolic process 1
that results of the conversion of energy 1
into metabolically useful forms by oxidation. 1

B. Without respiration, there would be no energy available for growth or maintenance of organisms. 1

Within the ecosystem, food chains are mechanisms by which energy from one organism is made available to subsequent organisms. There is a significant loss of energy from the ecosystem at each level. 2

Respiration is a mechanism for recycling carbon and water from organisms by way of the atmosphere. 2

Possible: 8

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdER.03
GUIDELINE OBJECTIVE CODE: 21kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, D.3
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS: free energy entropy oxidation

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to explain, in terms of the laws of thermodynamics, the release of energy when cellulose burns.

Item

Using the laws of thermodynamics, account for the fact that energy is released in the following equation, involving the burning of wood or paper:

$$\underset{\text{cellulose}}{[CH_2O]_n} + n(O_2) \longrightarrow \underset{\substack{\text{carbon}\\\text{dioxide}}}{n(CO_2)} + n(H_2O) + \text{Energy}$$

Response/Marking Scheme

In the equation, the cellulose is undergoing oxidation. If burning takes place, some of the released energy would be in the form of heat and light. This is simply 2

represented on the right hand side of the equation as "energy". The Second Law of Thermodynamics states that entropy or 2

disorder always increases. Although the 1

molecules of carbon dioxide and water are stable, they are 1

at lower energy levels (relative to the 1

cellulose) and can be thought of as being more random and less ordered. They also 2

possess less free energy, (where free energy is the energy available for doing work). 1

Possible: 10

Maximum: 8

Quality: 2

Total: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdER.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.8, A.9
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: chemical reactions	

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to relate the first law of thermodynamics to oxidative phosphorylation during cellular respiration.

Item

State the law of conservation of energy.

Explain oxidative phosphorylation, using the first law of thermodynamics, with reference to the chemical substances involved, and the site of the reactions within the cell.

Response/Marking Scheme

Energy is neither created nor destroyed; it is only converted from one form to another. 2

The energy for oxidative phosphorylation comes from the reduced coenzymes, $NADH + H^+$ and $FADH+H^+$, produced during glycolysis and the tricarboxylic acid (Krebs) cycle, from the chemical potential energy of glucose. 2

These reduced coenzymes are oxidized by oxidizing agents, proteins within the crista membrane of the mitochondria. 2

Electrons from the reduced coenzymes are transported through a series of oxidation-reduction reactions resulting in the transfer of hydrogen ions (protons) across the crista membrane. This creates a potential difference in proton concentration, and hence an electrical charge. 3

Some of the energy, therefore, has been converted from chemical potential to electrical potential energy. 1

This potential energy is converted back to chemical potential energy at the F_1 particle, where it bonds an inorganic phosphate ion to ADP to make ATP. 2

Not all the energy originally contained in the reduced coenzymes is converted to the energy of ATP. Some of it produced heat energy, and some became mechanical energy, but none of it was destroyed. 2

ATP will be used in turn to supply chemical, thermal, and mechanical energy for use by the cell and the organism. 1

Possible: 15

Maximum: 12

Quality: 2

Total: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KdER.08
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.8, A.9
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: entropy chemical reaction

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to explain cellular respiration in terms of the Second Law of Thermodynamics.

Item

State the Second Law of Thermodynamics.

Explain cellular respiration in terms of the second law of thermodynamics, including details of the reactants, products, energy relationships, and efficiency.

Response/Marking Scheme

As a system proceeds from a more organized state to a more random state, or entropy, the state of disorganization, increases. Free energy, the energy available to do work, always decreases.	2
Beginning with glucose, cellular respiration starts with	1
a considerable quantity of potential energy. As the	1
glucose is broken down into smaller molecules, its energy	1
is transferred to other molecules, such as coenzymes, and	1
some of it is changed to heat.	1
By the end of the Krebs (tricarboxylic acid) cycle, much	1
of the original energy has dissipated. There is a	1
further reduction in available potential energy during	1
the reactions of oxidation phosphorylation, until water is produced. The ATP produced during this process	1
contains much less energy than the original glucose.	1
As ATP is utilized to provide energy for cellular activity,	1
most of the energy remaining is released as heat.	1
The combustion of glucose releases approximately 2900 kJ	1
of energy per mole, mostly as heat. In cellular respiration, a mole of glucose might yield from 25 to 38 molecules of ATP.	1
Since each ATP molecule can generate about 31 kJ of energy, the total yield from one molecule of	1
glucose is from 775 to 1165 kJ of usable energy. Thus cellular respiration is about 30 – 40% efficient, and the	1
loss of free energy is about 60 – 70%.	

Possible: 17

Maximum: 12

Quality: 2

Total: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdER.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd Part 1 (3.2-8f)
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.8
TOPIC: Energy Transformations	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: laws of thermodynamics

Guideline Objective

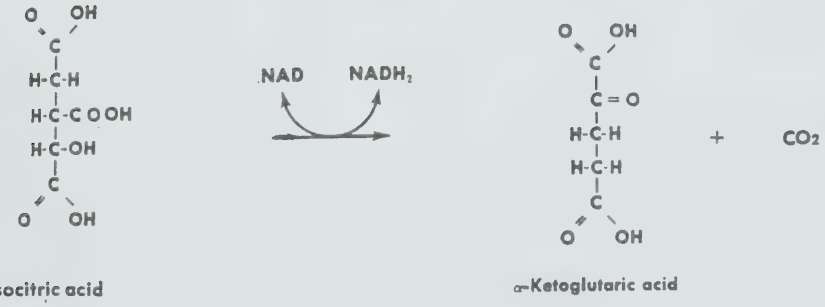
Students will be expected to describe in general terms how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and the living cell.

Item Focus

The students will account for a particular biochemical reaction in terms of the first and second laws of thermodynamics.

Item

Show how the first and second laws of thermodynamics apply to the following chemical reaction:



Isocitric acid

α-Ketoglutaric acid

Response/Marking Scheme

The carboxyl group containing carbon 1 is involved in the decarboxylation giving rise to carbon dioxide and one of the hydrogens involved in the reduction of NAD. 2

The remaining fragment along with an O-H from water forms the product on the far right of the equation. 2

The hydrogen from water is involved in the reduction of NAD. Thus all of the atoms in the reactants are accounted for in the products. 2

Furthermore, the energy in the reactants can be accounted for by assuming the first law and claiming that it is present in the 1

products and in forms such as heat that is released to the 1

environment during the reaction. This last statement is justified on the basis of the empirical claim that no known chemical reaction has a 100thermodynamics (conservation of mass-energy) has been applied and obeyed in this chemical reaction. 1

The generation of a gas, and the conversion of chemical potential energy into the form of heat energy demonstrate areas in the 1

reaction where the entropy has risen. This is in accordance with the second law (entropy levels rise in systems). 1

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Laws of Thermodynamics
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021KdSA.01R
GUIDELINE OBJECTIVE CODE: 21Kd 21Kg
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.8, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: free energy reduction potential aerobic respiration graphical analysis

Guideline Objective

Students will be expected to describe in general terms how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

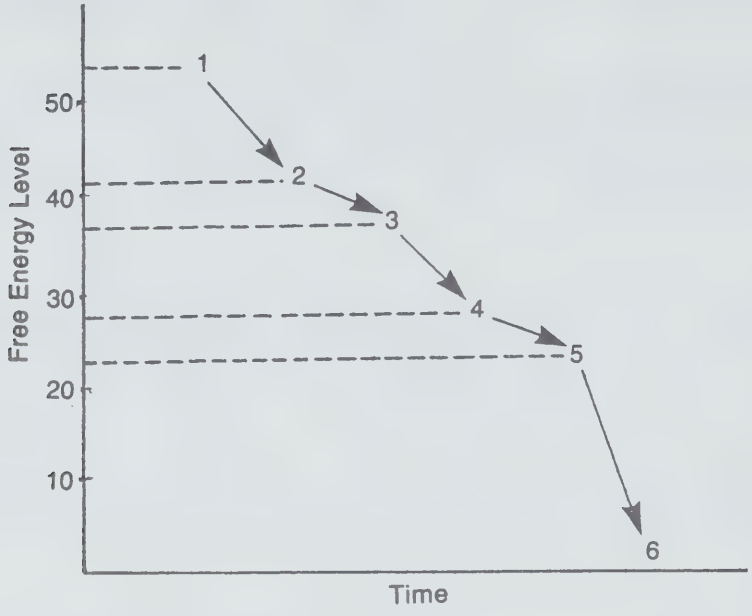
Item Focus

The student should be able to interpret a graph of the free energy at various steps in the electron transfer system.

Item

Refer to Figure 2K.11.

CHANGES IN ENERGY LEVEL IN MITOCHONDRIAL MEMBRANES



Symbols

1 - NADH+H$^+$

2 - flavoprotein

3 - cytochrome b

4 - cytochrome c

5 - cytochrome a

6 - cytochrome oxidase

Figure 2K.11 is a diagram of the energy relationships along the path of the electron pairs through the hydrogen electron transfer chain in a mitochondrial membrane during aerobic respiration.

A. What is the relationship between free energy and the reduction potential?

B. During this transfer of electrons, three pairs of hydrogen ions are transported across the mitochondrial membrane against their concentration gradient. From the data on the diagram,

   1. between which carrier molecules would you expect this active transfer to occur?

   2. Give reasons for your answer.

C. Which of the compounds shown on the diagram has the highest free energy (energy that would be released on oxidation)?

D. Which of the compounds shown on the diagram has the lowest reduction potential?

E.

1. What element finally accepts the electrons from the cytochrome oxidase?
2. Compare the free energy of this element with that of the cytochrome.
3. Compare the reduction potential of this element with that of the NADH.
4. What compound is formed as a result of the final redox reactions?

Response/Marking Scheme

A. As the free energy decreases, the reduction potential becomes more positive, i.e., less. 2

B.

1. Between NADH + H^+ and flavoprotein, 1

between cytochrome b and cytochrome c 1

between cytochrome a and cytochrome oxidase. 1

2. During these transfers, a greater amount of free energy is released than at other steps. 1

C. NADH + H^+ 1

D. cytochrome oxidase 1

E.

1. oxygen 1
2. oxygen has less free energy than cytochrome. 1
3. oxygen has a lower reduction potential than NADH. 1
4. water 1

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd
UNIT NUMBER: 02	INSTRUMENT TYPE: SA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.5, A.10
TOPIC: Aerobic Respiration	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: Krebs cycle	

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to generalize about the events leading to the release of energy from molecules.

Item

Below is a series of five formulae representing molecules found in the Krebs (tricarboxylic acid) cycle of respiration.

a. $C_4H_6O_4$

b. $C_6H_6O_6$

c. $C_5H_6O_5$

d. $C_6H_8O_6$

e. $C_4H_4O_4$

A. Rearrange the letters that appear beside the formulae in the correct sequence, starting with the molecule with the highest energy content and progressing to the molecule of lowest energy content. (You are not expected to have memorized this! Think it through logically).

B. When you have done this, explain carefully the logic you used in terms of the Krebs cycle.

Response/Marking Scheme

Correct sequence: d, b, c, a, e.

A. (Allow 1 mark for each compound in correct sequence.)	5
B. The molecules should be arranged in order of decreasing number of carbon atoms because,	1
in respiration, each decarboxylation is accompanied by oxidation and energy release.	1
Within a group of molecules having equal numbers of carbon atoms, they are placed on order of decreasing H : O ratio, because	1
each oxidation (energy release) will decrease the ratio.	1
Possible:	9
Maximum:	9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Aerobic Respiration
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B021KdSA.03
GUIDELINE OBJECTIVE CODE: 21Kd
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: energy levels oxidation

Guideline Objective

Students will be expected to describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to identify the compounds involved in aerobic respiration, and list them in order of decreasing energy levels.

Item

Six of the compounds shown below are involved only in the process of aerobic respiration. Select the numbers of the six, and list them in the boxes of the grid below in order of decreasing energy level.

1. ethanol
2. lactic acid
3. pyruvic acid
4. ribulose diphosphate
5. acetyl coenzyme A
6. diphosphoglyceric acid (DPGA)
7. glucose
8. phosphoglyceraldehyde (PGAL)
9. carbon dioxide

GRID:

Higher Energy | | | | | | | Lower Energy

Response/Marking Scheme

Selecting the correct six: (1 mark each)	6
Arranging in correct sequence: 7 6 8 3 5 9	2
Possible:	8
Maximum:	8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KdSA.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kd 21Kg
UNIT NUMBER: 02	INSTRUMENT TYPE: SA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.8, D.3
TOPIC: Laws of Thermodynamics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: aerobic respiration free energy graphical analysis

Guideline Objective

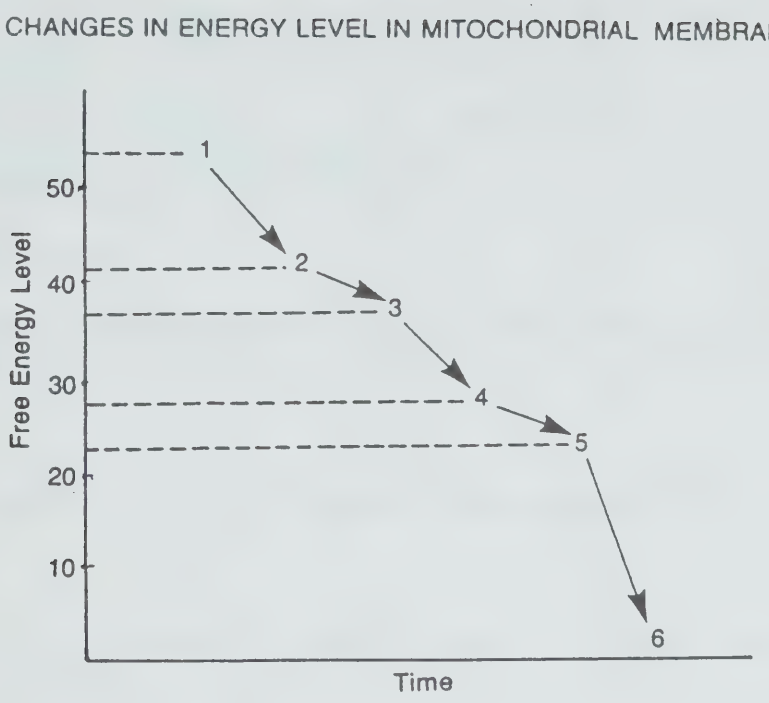
Students will be expected to describe in general terms how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell.

Item Focus

The student should be able to interpret a graph of the free energy at various steps in the electron transfer system.

Item

Refer to Figure 2K.12.



Symbols

1 - NADH + H^+

2 - flavoprotein

3 - cytochrome b

4 - cytochrome c

5 - cytochrome a

6 - cytochrome oxidase

Figure 2K.12 is a diagram of the energy relationships along the path of the electron pairs through the hydrogen electron transfer chain in a mitochondrial membrane during aerobic respiration.

Explain the changes shown in the diagram in terms of the second law of thermodynamics.

Response/Marking Scheme

As the electron pairs flow down the chain, there is a decline in the free energy available. 1

A smaller amount of energy is transferred at each successive step. 1

Possible: 2

Maximum: 2

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KeMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Ke
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.3
TOPIC: Anaerobic Metabolism	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: metabolism yeast

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify aspects of metabolism in different types of organisms.

Item

If the end products of a particular metabolic process in an organism are carbon dioxide and alcohol, then the organism is most likely

- ☐ A. a yeast.
- ☐ B. an alga.
- ☐ C. a virus.
- ☐ D. a green plant.
- ☐ E. an animal.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Metabolism
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.02
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: anaerobic respiration

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify a definition of the term anaerobic respiration.

Item

Which of the following is the best definition of anaerobic respiration?

Anaerobic respiration is

☐ A. a form of respiration making use of cytochromes.

☐ B. metabolism in the presence of ample oxygen.

☐ C. cellular metabolism in the absence of oxygen.

☐ D. cellular metabolism with adequate oxygen.

☐ E. respiration by a particular species of yeast.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.03
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: anaerobic respiration aerobic respiration

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify the essential features of anaerobic respiration.

Item

Aerobic and anaerobic respiration are alike in all of the following ways EXCEPT

- A. both can release energy from glucose.
- B. acetaldehyde is converted into ethanol.
- C. ADP is combined with inorganic phosphate to form ATP.
- D. carbon dioxide is a product.
- E. NAD^+ is reduced.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.04
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify the name, aerobic respiration, from its definition.

Item

What process involves the release of energy in a cell in the presence of an adequate supply of oxygen?

- [ ] A. anabolism
- [ ] B. glycolysis
- [ ] C. fermentation
- [ ] D. aerobic respiration
- [ ] E. anaerobic respiration

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.05
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify aspects of the definition of aerobic respiration.

Item

Aerobic respiration involves

- [ ] A. the release of energy in cells with an adequate supply of oxygen.
- [ ] B. breathing very rapidly, getting too much oxygen into the blood.
- [ ] C. the sequence of events in fermentation.
- [ ] D. the release of energy in cells without sufficient oxygen.
- [ ] E. the input of energy into cells without sufficient oxygen.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.06
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: chemical potential energy

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to recognize a definition of catabolism.

Item

The process that converts chemical potential energy into a form which can be used by cells is called

- [ ] A. transpiration.
- [ ] B. catabolism.
- [ ] C. translocation.
- [ ] D. anabolism.
- [ ] E. transcription.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.07
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: glycolysis

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify catabolic and anaerobic reactions.

Item

The biochemical pathway by which glucose is initially degraded may be described as

- [ ] A. aerobic and anabolic.
- [ ] B. anaerobic and catabolic.
- [ ] C. aerobic and catabolic.
- [ ] D. glycolytic and aerobic.
- [ ] E. catabolic and synthetic.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anabolic Reactions
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeMC.08
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: anabolism

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to identify anabolic reactions.

Item

In the following list, how many are anabolic processes?

digestion, respiration, photosynthesis, protein synthesis

- ☐ A. 0
- ☐ B. 1
- ☐ C. 2
- ☐ D. 3
- ☐ E. 4

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anaerobic Metabolism
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeSA.01
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: anaerobic respiration

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to define anaerobic respiration, and use the expression in a sentence to illustrate its meaning clearly.

Item

A. Define anaerobic respiration.

B. Give an example that illustrates this process.

Response/Marking Scheme

A. Anaerobic respiration is a form of metabolism 1
that does not require molecular oxygen 1
in order to convert substrate energy 1
into a form (ATP) 1
directly useful to the cell 1

B. Example similar to:
Decomposers, such as yeasts and some bacteria regularly use anaerobic respiration to obtain useful energy from carbohydrates, producing alcohols and carbon dioxide. 2

Possible: 7

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KeSA.02
GUIDELINE OBJECTIVE CODE: 21Ke 21Kd
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to define aerobic respiration and relate its importance to the functioning organism and the ecosystem.

Item

A. Define aerobic respiration.

B. What is the advantage of aerobic respiration to a functioning organism?

C. How does the type of respiration determine the distribution of some organisms in an ecosystem?

Response/Marking Scheme

A. Aerobic respiration is the oxidation of organic compounds in a cell in the presence of an adequate supply of oxygen. 2

B. Organisms can obtain much more usable energy from organic compounds using aerobic respiration than from anaerobic respiration. 2

C. In the ecosystem, some organisms can only live where there is enough oxygen; others can live in an absence of oxygen; and still others can adjust to either set of conditions. 3

Possible: 7

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: anabolism catabolism

INSTRUMENT CODE: B021KeSA.03
GUIDELINE OBJECTIVE CODE: 21Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

Students will be expected to explain the following terms: metabolism, catabolism, anabolism, aerobic metabolism, and anaerobic metabolism.

Item Focus

The student should be able to contrast anabolic and catabolic reactions.

Item

State two differences between anabolic and catabolic reactions.

Response/Marking Scheme

Any two contrasts at 2 marks each:

	Catabolic reactions	Anabolic reactions
Compounds are	broken down	synthesized
Energy is	released	stored
Type of reaction	hydrolysis	dehydration synthesis (condensation)

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: ATP
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KfMC.01
GUIDELINE OBJECTIVE CODE: 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: reduction

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to identify the functions of ATP.

Item

Which of the following processes does NOT use ATP?

- [ ] A. reduction of functional groups
- [ ] B. dehydration synthesis
- [ ] C. active transport
- [ ] D. muscle contraction
- [ ] E. bioluminescence

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Oxidative Phosphorylation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KfMC.02
GUIDELINE OBJECTIVE CODE: 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Krebs cycle

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to relate the hydrogen ion gradient across the crista membrane to the production of ATP.

Item

The role of water in oxidative phosphorylation is to

- [ ] A. supply electrons for the reduction of NADP
- [ ] B. supply hydrogen ions
- [ ] C. add hydrogen ions to pyruvic acid at the end of glycolysis
- [ ] D. hydrolyze carbohydrates
- [ ] E. accept electrons during the Krebs (TCA) cycle

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Electron Transport Chain
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KfMC.03
GUIDELINE OBJECTIVE CODE: 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ATP synthesis

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to identify the immediate source of the energy for the synthesis of ATP.

Item

In the electron transport chain the energy for the synthesis of ATP is obtained from

☐ A. oxygen.

☐ B. an electrochemical gradient across the inner mitochondrial membrane.

☐ C. the cytochrome enzymes.

☐ D. the dissociation of water.

☐ E. the combination of hydrogen ions, electrons and oxygen to form water.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Energy Transformations
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KfMC.04
GUIDELINE OBJECTIVE CODE: 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: active transport ATP

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to state the source of energy for major cell activities.

Item

The immediate source of energy for active transport is

☐ A. oxygen.

☐ B. glucose.

☐ C. ADP.

☐ D. $NADH + H^+(NADH_2)$.

☐ E. ATP.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KfMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kf 21Kd 11Ke
UNIT NUMBER: 02	
UNIT NAME: ENERGY AND THE LIVING CELL	INSTRUMENT TYPE: MC
	KLOPFER: A.1, A.2, A.3
TOPIC: Bond Energy	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: high energy bond ATP	

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to identify the meaning of 'high energy bond.'

Item

With respect to ATP, the term 'high energy bond' refers to

- ☐ A. only one of the bonds present in the molecule.
- ☐ B. the bond energies of two of the bonds present in the molecule.
- ☐ C. three of the bonds present in the molecule.
- ☐ D. the ribose sugar part of the molecule.
- ☐ E. the amount of free energy available when the bond is broken.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Oxidation/Reduction
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KfMC.06
GUIDELINE OBJECTIVE CODE: 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: redox reactions

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to identify the roles of major co-enzymes.

Item

Which substance does NOT participate in redox reactions?

- [ ] A. ATP
- [ ] B. FAD
- [ ] C. Cytochrome *c*
- [ ] D. NAD
- [ ] E. NADP

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Synthesis of ATP
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KfMC.07
GUIDELINE OBJECTIVE CODE: 21Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: ADP ATP

Guideline Objective

Students will be expected to describe the synthesis of ATP (adenosine triphosphate), and its use in the cell.

Item Focus

The student should be able to identify significant differences in structure between ADP and ATP.

Item

An ADP molecule differs from an ATP molecule in that ADP

- [ ] A. has two fewer phosphate groups.
- [ ] B. has less stored energy.
- [ ] C. has more free energy.
- [ ] D. contains three high energy bonds.
- [ ] E. has one more phosphate group.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KfSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kf
UNIT NUMBER: 02	INSTRUMENT TYPE: SA
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: ATP Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: structural formulae types of chemical reactions

Guideline Objective

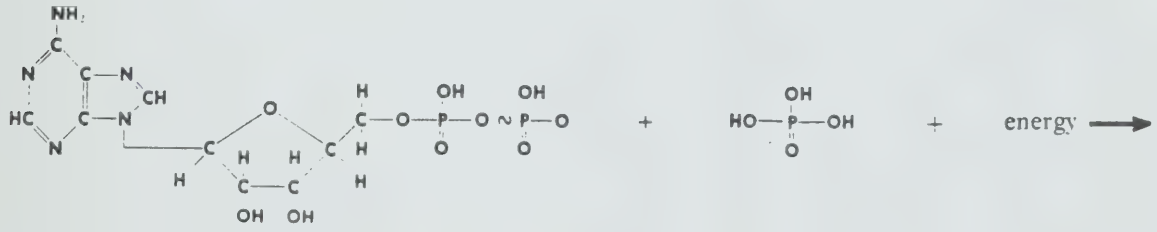
The students will describe the synthesis of ATP (adenosine triphosphate) and its use in the cell.

Item Focus

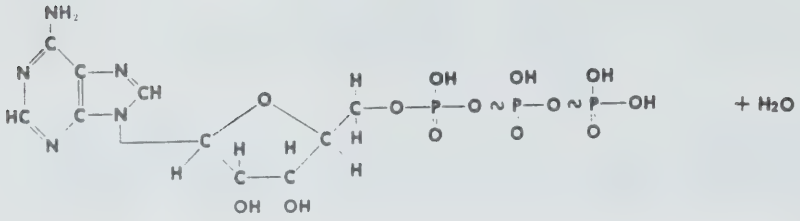
The student will predict the products of reactions based on their knowledge of functional groups.

Item

Complete the following reaction using structural formulae, and identify the products:



Response/Marking Scheme



2

The products are adenosine triphosphate (ATP) and water. 2

Possible: 4

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KgMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kg 21Kb 31Ki
UNIT NUMBER: 02	
UNIT NAME: ENERGY AND THE LIVING CELL	INSTRUMENT TYPE: MC
TOPIC: Metabolism	KLOPFER: A.1, A.2, A.3, A.11
CURRICULAR EMPHASIS: Solid Foundations	DIFFICULTY LEVEL: M
	TIME ALLOCATION:

KEYWORDS: active transport extracellular digestion photosynthesis

Guideline Objective

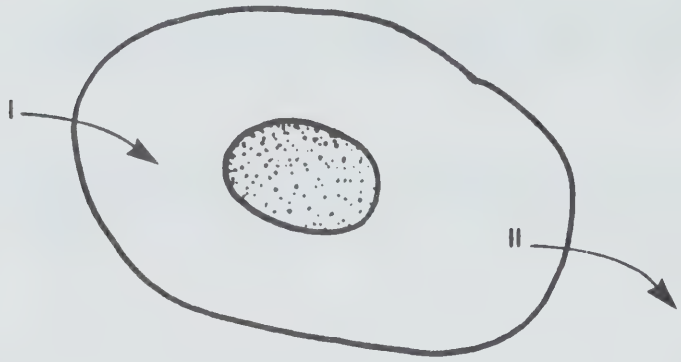
Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify aspects of metabolism in different organisms.

Item

Questions 1 to 3 are based on the following diagram representing a living cell. Arrow I represents materials that normally are required by the organism. Arrow II represents materials that normally move out of the organism.



1. If the cell is from an animal, arrow I would most likely represent

☐ A. carbon dioxide and nitrogenous wastes.

☐ B. products of extracellular digestion.

☐ C. products of intracellular digestion.

☐ D. enzymes and ATP.

☐ E. carbon dioxide.

2. If the cell is a green leaf cell from a plant in sunlight, arrow II would most likely represent

- [ ] A. amino acids and water.
- [ ] B. glucose and carbon dioxide.
- [ ] C. water and oxygen.
- [ ] D. products of extracellular digestion.
- [ ] E. products of photosynthesis.

3. If this is a unicellular fresh-water organism and arrow II represents the removal of excess water, the process involved would most likely be

- [ ] A. diffusion.
- [ ] B. active transport.
- [ ] C. pinocytosis.
- [ ] D. plasmolysis.
- [ ] E. peristalsis.

Response/Marking Scheme

Correct response for question 1: B
Correct response for question 2: E
Correct response for question 3: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.02
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: electron transport chain

Guideline Objective

The student will be expected to explain the relationship among glycolysis, the citric-acid (Krebs) cycle, and the electron transport (respiratory) chain abd indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the final product of the electron transport chain.

Item

The final product of the electron transport chain in cellular respiration is a molecule of

☐ A. water.

☐ B. ATP.

☐ C. co-enzyme A.

☐ D. pyruvic acid.

☐ E. cytochrome oxidase.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.03
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: mitochondria

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the site of the production of ATP in aerobic respiration.

Item

Proteins are to ribosomes as ATP is to the

- [ ] A. nucleus.
- [ ] B. chromosomes.
- [ ] C. Golgi apparatus.
- [ ] D. mitochondria.
- [ ] E. centrioles.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.04
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the form in which the oxygen removed from the environment for cellular respiration returns to the environment.

Item

Oxygen removed from the environment and used in cellular respiration is returned to the environment combined with

- [ ] A. carbon or hydrogen.
- [ ] B. glucose or nitrogen.
- [ ] C. nitrates or sulphates.
- [ ] D. carbon only.
- [ ] E. ATP or phosphates.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.05
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: acrobic respiration glycolysis

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify some of the key steps in glycolysis.

Item

The first step in the activation of glucose for respiration is the

- [ ] A. removal of a molecule of water.
- [ ] B. addition of a hydrogen ion.
- [ ] C. removal of an atom of oxygen.
- [ ] D. addition of a phosphate group.
- [ ] E. addition of an atom of oxygen.

Response/Marking Scheme

Correct reponse: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KgMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kg
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cellular Respiration	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: energy ATP

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to recognize the central importance of cellular respiration in the metabolic processes of cells.

Item

The energy immediately available for use by living cells is provided in

- ☐ A. starch.
- ☐ B. fats.
- ☐ C. ADP.
- ☐ D. glucose.
- ☐ E. ATP.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.07
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: electron transport chain

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the final destination of the electrons passing through the electron transport chain during aerobic respiration.

Item

During cellular respiration, the final product that contains most of the hydrogen electrons passing through the electron transport chain is

- [ ] A. water.
- [ ] B. ATP.
- [ ] C. chlorophyll.
- [ ] D. oxygen.
- [ ] E. cytochrome oxidase.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Aerobic Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.08
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: acetyl coenzyme A citric acid (Krebs) cycle

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the substance that activates the citric acid (Krebs) cycle in aerobic respiration.

Item

Which of the following molecules activates the citric acid (Krebs) cycle during aerobic cellular respiration?

- ☐ A. carbon dioxide
- ☐ B. acetyl coenzyme A
- ☐ C. cytochrome oxidase
- ☐ D. pyruvic acid
- ☐ E. citric acid

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Aerobic Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.09
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: cellular respiration oxidation reduction electron transport chain

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the part of the process of cellular metabolism that makes use of the oxidation/reduction of iron-containing cytochrome molecules.

Item

During aerobic cellular respiration, oxidation/reduction reactions involving Fe^{2+} and Fe^{3+} occur during

- [ ] A. glycolysis.
- [ ] B. the electron carrier chain
- [ ] C. the citric acid (Krebs) cycle.
- [ ] D. glycogenesis.
- [ ] E. fermentation.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Glycolysis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.10
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to state how carbohydrates enter the glycolytic pathway.

Item

Before carbohydrates enter the glycolytic pathway of an animal, they must

I be digested.
II gain a phosphate (phosphoryl) group.
III be absorbed through the lining of the small intestine.
IV cross a cell membrane.

Select your response from the following

☐ A. I only

☐ B. I and II only

☐ C. I and IV only

☐ D. I, III, and IV only

☐ E. I, II, III, and IV

Response/Marking Scheme

Correct response: E

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Glycolysis
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: NADP

INSTRUMENT CODE: B021KgMC.11
GUIDELINE OBJECTIVE CODE: 21Kg 11Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10, D.4, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify likely sites of reduction in a metabolic sequence.

Item

Refer to Figure 2K.13.

A SERIES OF CELLULAR METABOLIC REACTIONS

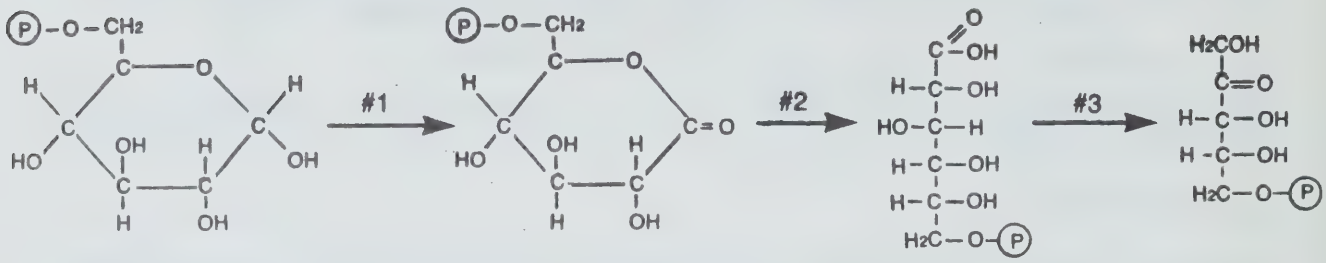


Figure 2K.13 shows three of a series of metabolic reactions occurring in cells. Where, in the sequence, would you expect NADP to be reduced as the reaction proceeds?

- A. reaction 1
- B. reaction 2
- C. reaction 3
- D. reaction 1 and also reaction 3
- E. reaction 1, reaction 2, and also reaction 3

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Decarboxylation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgMC.12
GUIDELINE OBJECTIVE CODE: 21Kg 11Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.10, D.4, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: metabolism

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify likely sites of decarboxylation in a metabolic sequence.

Item

Refer to Figure 2K.13 at this point.

A SERIES OF CELLULAR METABOLIC REACTIONS

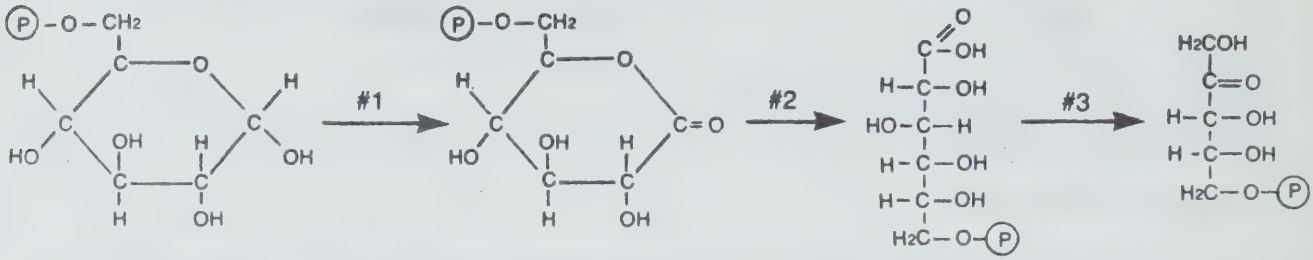


Figure 2K.13 shows three of a series of metabolic reactions occurring in cells. Where, in the sequence, would you expect to observe decarboxylation?

A. reaction 1

B. reaction 2

C. reaction 3

D. reaction 1 and also reaction 3

E. reaction 1, reaction 2, and also reaction 3

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Electron Transport Chain
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KgER.02
GUIDELINE OBJECTIVE CODE: 21Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: cytochromes oxidation/reduction

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify the role of the cytochrome molecules in the electron transport chain, and explain the relationship of oxygen and hydrogen to the chain.

Item

Refer to Figure 2K.14.

ELECTRON TRANSPORT CHAIN

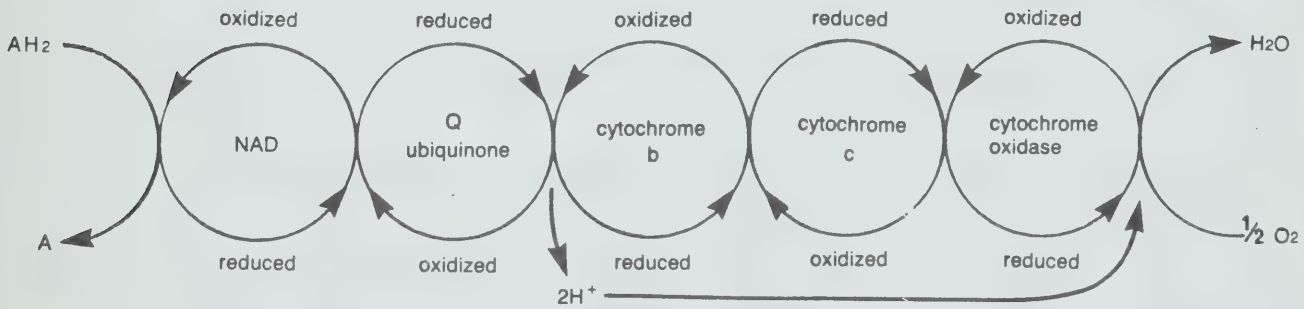


Figure 2K.14 is a diagram representing the electron transport chain.

A. What is the original source in the cell of the hydrogen atoms that start down the chain?

B. With reference to cytochrome *b* show how the same substance can act as both an oxidizing and a reducing agent.

C. What is the role of oxygen in cellular respiration? How is this role accomplished?

Response/Marking Scheme

A. The hydrogen atoms were originally part of a nutrient molecule such as carbohydrate, lipid, or amino acid. 1

B. When cytochrome *b* receives an electron from 1
coenzyme Q, 1
it acts as an oxidizing agent, and is reduced. 2
The iron ion changes valence from +3 to +2. 1
When cytochrome *b* gives up an electron to 1
cytochrome *c*, 1
it is oxidized, as it acts as a reducing agent, 2
and the valence of the iron ion changes back from +2 to +3. 1

C. Each oxygen atom is the final electron acceptor for low energy electrons that have passed 1
along the chain, and combines with 2 hydrogen ions 1
to form a molecule of water. 1

Possible: 14

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KgMA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kg 31Kc 31Kg
UNIT NUMBER: 02	
UNIT NAME: ENERGY AND THE LIVING CELL	INSTRUMENT TYPE: MA
	KLOPFER: A.1, A.2, A.3
TOPIC: Energy Transformation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: oxidative phosphorylation acetyl-coenzyme A photophosphorylation

Guideline Objective

Students will be expected to explain the relationship among glycolysis, the citric acid (Krebs) cycle, and the electron transport (respiratory) chain and indicate the reactants, products, and location of each in the cell.

Item Focus

The student should be able to identify symbols and compounds related to the mechanisms of energy storage and release.

Item

In the space provided, match the expression in the left column with the most appropriate response from the right column.

1. C	reduced in the 'dark reaction'	A.	ATP
2. G	accepts 'waste electrons' in oxidative phosphorylation	B.	cAMP
3. H	carries acetyl-Coenzyme A into the Krebs cycle	C.	CO_2
4. D	source of electrons and H^+ in photophosphorylation and photoreduction	D.	H_2O
5. A	most commonly used non-redox energy molecule.	E.	NAD
		F.	NADP
		G.	O_2
		H.	OAA

Response/Marking Scheme

1. - C, 2. - G, 3. - H, 4. - D, 5. - A

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KhMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kh
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cellular Respiration	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: anaerobic respiration	

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to identify aspects of the ecosystem and human activities that make use of anaerobic respiration

Item

All but one of the following processes involve anaerobic metabolism. Which of the following processes does NOT involve anaerobic respiration?

- ☐ A. Sewage breaks down in a septic tank.
- ☐ B. Alcohol is produced in fermentation.
- ☐ C. Soil bacteria help to decompose compost.
- ☐ D. Nitrogen is fixed by means of certain soil bacteria.
- ☐ E. It is the action of yeast that causes bread dough to rise.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KhMC.02
GUIDELINE OBJECTIVE CODE: 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: anaerobic respiration

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to identify the sources of energy for anaerobic respiration.

Item

Which of the following can be used by yeast cells for anaerobic respiration?

- [ ] A. glucose
- [ ] B. sucrose
- [ ] C. fructose
- [ ] D. maltose
- [ ] E. all of the above

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Aerobic Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KhMC.03
GUIDELINE OBJECTIVE CODE: 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.6, F.1
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: anaerobic respiration

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to recognize that metabolism in the brain is aerobic, in contrast to a number of anaerobic situations.

Item

In which of the following places would you LEAST expect to find anaerobic respiration occurring?

- [ ] A. in sediments at the bottom of a marsh
- [ ] B. in a human brain engaged in writing a test
- [ ] C. in a sprinter's leg muscles, during a 100 m dash
- [ ] D. in the tissues of a tapeworm occupying a human intestine
- [ ] E. in a vat in which beer is being manufactured

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KhMC.04
GUIDELINE OBJECTIVE CODE: 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to identify the advantage of aerobic respiration to the organism.

Item

Aerobic respiration is more efficient than anaerobic respiration because

- [ ] A. most animals have to breathe air.
- [ ] B. only bacteria and yeasts use anaerobic respiration.
- [ ] C. the blood usually carries sufficient oxygen to the cells.
- [ ] D. aerobic respiration allows fast oxidation during heavy exercise.
- [ ] E. more ATP is ultimately made available per molecule metabolized.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KhMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kh
UNIT NUMBER: 02	INSTRUMENT TYPE: MC
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3
TOPIC: Cellular Respiration	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: aerobic respiration

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to identify the advantage of aerobic respiration to an animal.

Item

The advantage of aerobic respiration to an animal is that it

- ☐ A. cannot release energy from food by anaerobic respiration.
- ☐ B. must always use aerobic respiration for movement.
- ☐ C. obtains more usable energy by aerobic respiration.
- ☐ D. must always use anaerobic respiration for movement.
- ☐ E. cannot obtain more usable energy from food by aerobic respiration.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Glycolysis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KhMC.06
GUIDELINE OBJECTIVE CODE: 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic respiration energy

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to identify a product of glycolosis.

Item

At the completion of glycolysis, the bulk of the energy from glucose undergoing aerobic respiration is found in molecules of

- [ ] A. lactic acid.
- [ ] B. ATP.
- [ ] C. pyruvic acid.
- [ ] D. reduced NAD.
- [ ] E. phosphoglyceraldehyde (PGAL).

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KhMC.07
GUIDELINE OBJECTIVE CODE: 21Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: glycolysis

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to identify the difference between cellular respiration and combustion.

Item

When glucose burns in air, it releases heat rapidly. In the cellular respiration of glucose

- [ ] A. no heat is released.
- [ ] B. no oxygen is required.
- [ ] C. water prevents uncontrolled combustion.
- [ ] D. enzymes make the reaction take place in small steps.
- [ ] E. all of the energy is converted into ATP.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KhSA.01
GUIDELINE OBJECTIVE CODE: 21Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1; A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: aerobic anaerobic

Guideline Objective

Students will be expected to explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis, and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Item Focus

The student should be able to state the differences between aerobic and anaerobic respiration.

Item

Complete the following table, giving the differences between aerobic and anaerobic respiration.

FEATURE COMPARED	AEROBIC	ANAEROBIC
Molecular oxygen		
Energy efficiency		
Site		
Products		
Organelle		

Response/Marking Scheme

(5 contrasts × 1 mark each)

FEATURE COMPARED	AEROBIC	ANAEROBIC
Molecular oxygen	present	absent/inadequate
Energy efficiency	higher	lower
Site	only in some cells	in all cells
Products	water	lactic acid or ethanol
Organelle involved	mitochondria and cytoplasm	cytoplasm only

Possible: 5

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anaerobic Respiration
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B021KiMC.01
GUIDELINE OBJECTIVE CODE: 21Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: lactic acid

Guideline Objective

Students will be expected to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue, resulting in muscle fatigue.

Item Focus

The student should be able to identify the process by which muscles obtain energy when oxygen supply is inadequate.

Item

When you are exercising vigorously, your muscle cells are unable to obtain oxygen from your blood at a sufficient rate. As a result, the muscle cells

☐ A. stop functioning, resulting in cramps.

☐ B. activate anaerobic metabolism, producing lactic acid and releasing energy.

☐ C. get their energy from oxidative phosphorylation instead.

☐ D. use the 4-carbon shunt as an alternative source of energy.

☐ E. use lactic acid to synthesize glycogen for the glycolytic pathway.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anaerobic Respiration
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B021KiER.01
GUIDELINE OBJECTIVE CODE: 21Ki
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: oxidative phosphorylation lactic acid

Guideline Objective

Students will be expected to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue resulting in muscle fatigue.

Item Focus

Same as above.

Item

A. In active muscle tissue, when the supply of oxygen is not adequate for the demands of oxidative phosphorylation, how does catabolism proceed?

B. What is the significance of the change in metabolism described in part A?

Response/Marking Scheme

A. Glycolysis continues to supply small amounts of ATP,	1
which produces lactic acid, that accumulates.	2
Muscle cells become more acidic, reducing the sliding effect of myofibrils.	2
Creatine phosphate generates more ATP from ADP.	2
B. The process of anaerobic respiration (catabolism) is	1
significant in allowing movement to continue in a crisis,to meet a short-lived energy demand.	1
This might allow a mammal to flee from a predator, or to put on a burst of speed to overcome its prey, in either case, enhancing survival.	1

Possible: 10

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anaerobic Respiration
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B021KiER.02
GUIDELINE OBJECTIVE CODE: 21Ki
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.9
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS: catabolism

Guideline Objective

Students will be expected to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue, resulting in muscle fatigue.

Item Focus

The student should be able to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue.

Item

Explain the significance of anaerobic catabolism in active muscle tissue.

Response/Marking Scheme

During strenuous exercise, active muscle tissue is respiring rapidly	1
The supply of oxygen may become insufficient.	1
Since oxygen is the final electron acceptor in the hydrogen-electron transport chain,	1
there would be nowhere for the final reduced enzyme in the chain to unload its electrons.	1
This would cause an accumulation of reduced enzymes through the whole chain	1
which eventually would cause the accumulation of NADH,	1
since it is unable to pass its electrons into the chain.	1
This effectively stops glycolysis and the Krebs cycle.	1
During such a situation, pyruvic acid is used as an alternate electron acceptor.	1
The NADH donates its electrons to the pyruvic acid, which is converted into lactic acid.	1
This reforms a small quantity of NAD^+,	1
enabling glycolysis to proceed and produce a net gain of 2 ATP for each glucose molecule broken down.	1
Anaerobic respiration is much less efficient than aerobic respiration,	1
however, it does provide a minimal supply of ATP when oxygen is not available.	1
Possible:	14
Maximum:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anaerobic Respiration
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B021KiER.03
GUIDELINE OBJECTIVE CODE: 21Ki
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be expected to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue, resulting in muscle fatigue.

Item Focus

The student should be able to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue.

Item

During anaerobic conditions in active muscle tissue, pyruvic acid is converted to lactic acid. Explain the physiological significance of this change.

Response/Marking Scheme

A lack of oxygen, the final electron acceptor,	1
causes an accumulation of reduced electrons	1
in the electron transport chain,	1
causing an accumulation of NADH + H^+.	1
The NADH donates its electrons to the pyruvic acid, which is converted into lactic acid.	1
This reforms a small quantity of NAD^+,	1
enabling glycolysis to proceed and produce a net gain of 2 ATP for each glucose molecule broken down.	1
Anaerobic respiration is much less efficient than aerobic respiration,	1
however, it does provide a minimal supply of ATP when oxygen is not available.	1
Possible:	9
Maximum:	5

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Anaerobic Respiration
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B021KiER.04
GUIDELINE OBJECTIVE CODE: 21Ki
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: lactic acid

Guideline Objective

Students will be expected to explain the significance of anaerobic catabolism and the build up of lactic acid in active muscle tissue resulting in muscle fatigue.

Item Focus

The student should be able to explain the energy relationships and chemistry of anaerobic respiration in muscle cells.

Item

Explain why it is essential that muscle cells, during anaerobic respiration, convert pyruvic acid (pyruvate) into lactic acid, even though the conversion consumes metabolic energy, and the accumulation of lactic acid causes muscle fatigue.

Response/Marking Scheme

Muscle contraction consumes ATP, a form of energy	1
that can be regenerated in the absence of oxygen by substrate-linked phosphorylation	1
in the glycolytic pathway.	1
Oxidized NAD is an obligatory participant in this pathway	1
in which it becomes reduced.	1
Since the energy of reduced NAD cannot be used to phosphorylate ADP in the absence of oxygen,	1
and there are no redox reactions occurring in muscle cells	1
to reoxidize NAD, only the reduction of pyruvic acid to	1
lactic acid can regenerate oxidized NAD	1
so that glycolysis can continue.	1
	Possible: 10
	Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KjMC.01
GUIDELINE OBJECTIVE CODE: 21Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: fats proteins

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

The student should be able to identify the molecules by which proteins and fats enter the respiratory pathway.

Item

Fats and proteins may be used in respiration if they are first converted, respectively, into

☐ A. acetyl CoA and oxaloacetic acid.

☐ B. oxaloacetic acid and citric acid.

☐ C. citric acid and pyruvic acid.

☐ D. acetyl CoA and pyruvic acid.

☐ E. lactic acid and pyruvic acid.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KjMC.02
GUIDELINE OBJECTIVE CODE: 21Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: fatty acid Krebs cycle

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

The student should be able to identify the compound derived from fats that can enter the Krebs cycle.

Item

Fatty acids enter the Krebs (citric acid) cycle as

- [ ] A. oxaloacetic acid
- [ ] B. phosphoglyceraldehyde (PGAL)
- [ ] C. α-ketoglutaric acid
- [ ] D. pyruvic acid
- [ ] E. acetyl-Coenzyme A

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KjMC.03
GUIDELINE OBJECTIVE CODE: 21Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino acid Krebs cycle

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

The student should be able to identify the number of sites at which amino acid residues can enter the Krebs cycle.

Item

The number of sites at which the carbon skeletons of amino acids can enter the Krebs (citric acid) cycle is

☐ A. 0.

☐ B. 1.

☐ C. 2.

☐ D. 3.

☐ E. 4.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KjMC.04
GUIDELINE OBJECTIVE CODE: 21Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: amino acids

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

The student should be able to identify the mechanism by which amino acids can enter the pathway of cellular respiration.

Item

Before an amino acid can enter the pathway of cellular respiration, it must be

- [ ] A. converted into protein.
- [ ] B. converted into glucose.
- [ ] C. phosphorylated.
- [ ] D. hydrolyzed.
- [ ] E. deaminated.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KjMC.05
GUIDELINE OBJECTIVE CODE: 21Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: citric acid cycle fatty acids

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

The student should be able to identify the way derivatives of fats can enter the respiratory pathway.

Item

Fatty acids are used as a source of energy in the citric acid (Krebs) cycle pathway of cellular respiration, but they must first be converted into

☐ A. glucose.

☐ B. amino acids.

☐ C. citric acid.

☐ D. acetyl CoA (co-enzyme A).

☐ E. pyruvic acid.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Cellular Respiration
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B021KjER.01
GUIDELINE OBJECTIVE CODE: 21Kj
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: fat glycolysis citric acid cycle

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

Same as above.

Item

Fats can be used in the body to generate energy. Explain, in a general way, how fats must be changed before they can enter glycolysis and the citric acid (Krebs) cycle.

Response/Marking Scheme

Fat is hydrolysed	1
into glycerol and fatty acids.	1
The glycerol enters glycolysis (at the 3-C stage).	1
The fatty acids are broken down to (2-C) acetyl-CoA	1
which feeds into the citric acid cycle.	1
Possible:	5
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B021KjER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 21Kj
UNIT NUMBER: 02	INSTRUMENT TYPE: ER
UNIT NAME: ENERGY AND THE LIVING CELL	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Cellular Respiration	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: protein glycolysis citric acid cycle

Guideline Objective

Students will be expected to describe in, general terms, how derivatives of fats and proteins can by enter the glycolytic and citric-acid cycle pathways to produce usable energy.

Item Focus

Same as above.

Item

Proteins can be used in the body to supply energy. Explain, in a general way, how proteins must be changed in order to enter glycolysis and the citric acid cycle.

Response/Marking Scheme

The protein can be hydrolysed	1
into amino acids	1
which are deaminated	1
into various compounds which enter the glycolytic pathway	1
at the level of pyruvic acid and acetyl coA	2
Other carbon skeletons feed into the citric acid cycle	1
at the level of α-ketoglutaric acid or oxaloacetic acid	2
Possible:	9
Maximum:	6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELL
TOPIC: Aerobic/Anaerobic Respiration
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: fermentation catabolism lab

INSTRUMENT CODE: B022c-LE.01
GUIDELINE OBJECTIVE CODE: 22c
INSTRUMENT TYPE: LE
KLOPFER: A.1, A.2, A.3, B.1, B.3, B.5, D.1, D.3, G.2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

Students will be expected to perform experiments to investigate the type and quantity of end products of aerobic and anaerobic catabolism.

Item Focus

The students should be able to measure and compare the end products of aerobic and anaerobic respiration by yeast.

Item

In this laboratory exercise, you are to measure the products of the cellular respiration of yeast during two sets of conditions, aerobic and anaerobic. By comparing the results, you will be able to make inferences about the nature of aerobic and anaerobic catabolism.

The measurements of the carbon dioxide released by the respiration of the yeast are to be made on the basis of two reactions. First, the carbon dioxide will react with limewater to produce a precipitate of calcium carbonate:

$$\underset{44g}{CO_2(g)} + \underset{74g}{Ca(OH)_2} \longrightarrow CaCO_3(s) + H_2O$$

While the mass of calcium carbonate could be used as a measure of the amount of carbon dioxide released by the yeast, a more sensitive measure is the amount of calcium hydroxide left in the limewater. This is measured by titration against 0.1 mol/L hydrochloric acid, which contains 3.65 g of HCl/L, and is thus equivalent to 2.2 g of carbon dioxide.

$$2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$$

The end point of this reaction occurs when the red phenolphthalein just becomes colourless.

Procedure:

1. Set up the apparatus as shown in Figure 2-2-1. Label the culture flasks #1 and #2.

2. Measure 1.0 g of dry yeast into each of the two culture flasks.

3. Measure 10.0 mL of the glucose solution into each of the two culture flasks.

4. Slowly pour the oil down the side of flask #2 to cover the surface of the culture. This will prevent air from reaching the yeast, making #2 the anaerobic culture.

5. Set the two culture test tubes into the water bath, surrounded by warm water (not over 40°C).

6. Measure 10.0 mL of limewater into each of three test tubes. Set two of the tubes so that the delivery tubes from the yeast cultures reach to the bottom. Label them to match the numbers of their culture, #1 and #2. The remaining tube of limewater is a control. Label it #3, and set it into the test tube rack.

7. Add 1 drop of phenolphthalein indicator solution to each of the tubes of lime water.

8. After 30 min, or when the phenolphthalein in one of the tubes becomes colourless, remove the delivery tubes.

9. Label the remaining clean test tubes #1, #2, and #3. Filter each of the tubes of limewater into the corresponding clean test tubes, using a fresh filter paper for each.

10. Titrate each of the filtrates with 0.1 mol/L hydrochloric acid, swirling the test tubes frequently until the indicator becomes colourless. Record the volumes of acid needed to neutralize the lime water in each case.

11. Pour the contents of culture flasks #1 and #2 into the correct cylinders your teacher will provide. When enough has been collected, use the hydrometer to measure the specific gravity of the liquid.

Questions:

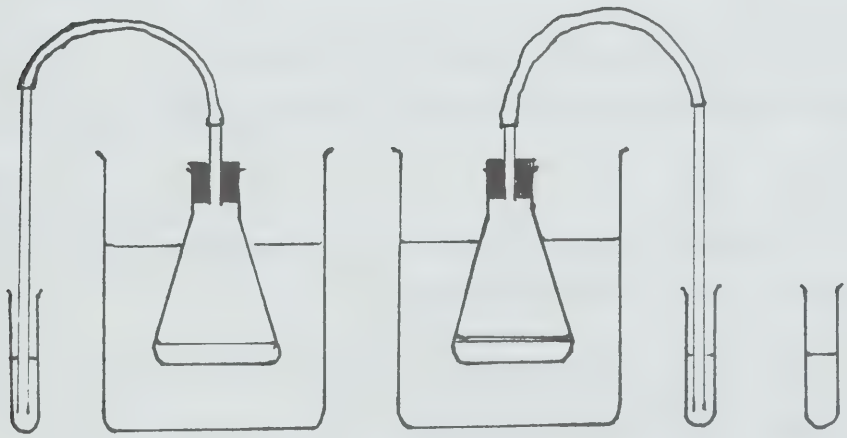
1. How much carbon dioxide had reacted with the lime water from culture tubes #1 and #2?

2. Why was the third test tube of limewater added?

3. How much ethanol had been produced in culture tubes #1 and #2?

4. For yeast cells to produce ethanol, should conditions be aerobic or anaerobic?

5. Write word equations for the respiration of yeast cells in the presence of glucose with and without the presence of air.



Response/Marking Scheme

Technique of measuring mass and volume — 5

Records and Calculations: (answers will vary)

Titration with 0.1 mol/L hydrochloric acid:

1.

Test tube:	#1	#2	#3	
Volume of Acid:	0.3 mL	1.0 mL	3.0 mL	3
Equivalent of carbon dioxide:	0.3 g	0.8 g	2.4 g	3
Thus, carbon dioxide reacted with lime water:	2.1 g	1.6 g	0 (control)	3

The aerobic culture produced more carbon dioxide than the anaerobic culture. — 1

2. The third test tube is the control, to determine how much lime water will remain unaffected by the carbon dioxide in the air. — 2

3. Answers will vary. — 1

4. Anaerobic conditions produce alcohol, while aerobic conditions convert glucose into water and carbon dioxide. — 1

5. glucose + oxygen $\xrightarrow[\text{aerobically}]{\text{yeast}}$ carbon dioxide + water — 2

   glucose $\xrightarrow[\text{anaerobically}]{\text{yeast}}$ carbon dioxide + ethanol — 2

Possible: 23

Maximum: 20

Teacher Notes

1. This laboratory exercise allows students to see the difference between the processes of aerobic and anaerobic respiration by measuring the carbon dioxide and alcohol produced during the different conditions.

2. The carbon dioxide is measured by titration of limewater with hydrochloric acid using phenolphthalein as the indicator. The alcohol might be measured using a hydrometer. (Alternatively, the alcohol could be detected by fractional distillation: it would be the component of the mixture that boils at 78.5°C.)

3. Allow a 70 min period for the lab.

Materials: (per student)

2	erlenmeyer flasks, 250 mL
6	test tubes, 15 × 150 mm
1	burette, 100 mL
1	flask, 250 mL
2	beaker, 600 mL
	balance
	graduated pipette
	hydrometer
	dropper with long glass tube
	glass tubing
	rubber stoppers, 2 - holed
	funnel
3	filter papers
2g	yeast, active, dry
20 mL	hydrochloric acid, 0.1 mol/L
45 mL	limewater
	phenolphthalein solution
10 mL	cooking oil (corn oil)

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 02
UNIT NAME: ENERGY AND THE LIVING CELLL
TOPIC: Energy Transformations
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B024b-EE.01
GUIDELINE OBJECTIVE CODE: 24b
INSTRUMENT TYPE: EE
KLOPFER: A.1, A.2, A.3, F.2, I.4
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: physical fitness, aerobic and anaerobic respiration.

Guideline Objective

The student will understand how the application of our knowledge of cells has led to improved medical, dietary, and physical-fitness procedures.

Item Focus

The student will develop arguments for the positive and negative aspects of vigorous physical exercise such as jogging and aerobic exercise.

Item

A number of people have become involved with physical activities such as jogging and aerobic exercises. Along with the enjoyment that some people experience from physical exercise, many feel that these activities lead to better health and physical fitness.

Critics argue that, potentially, more harm than good can result from these activities.

Discuss the two points of view with reference to aerobic and anaerobic respiration.

Response/Marking Scheme

Because the product of glycolysis (anaerobic respiration) is the reactant for Krebs cycle (aerobic respiration), glucose must undergo anaerobic respiration before aerobic respiration. 1

However, reduced NAD, one of the important products of the Krebs cycle, enters the hydrogen-electron carrier system 1

which requires molecular oxygen in order for the reaction to proceed. 1

A second key product of aerobic respiration is carbon dioxide gas, 1

the result of decarboxylation. 1

If sufficient molecular oxygen cannot be supplied to cells, then reduced NAD cannot be processed in the hydrogen-electron carrier system, 1

and ultimately the Krebs cycle slows down (law of mass action). 1

This leads to an accumulation of the product of anaerobic respiration, pyruvic acid. 1

Excess pyruvic acid is converted into lactic acid. 1

Excess lactic acid builds up in muscle cells. 1

Furthermore, when levels of lactic acid become excessively high, lactic acid diffuses into the bloodstream where it is carried throughout the body. 1

Excessively high levels of lactic acid have deleterious effects on the body. 1

Exercise is thought to improve the body's effiency in conducting molecular oxygen to cells, 1

hence increasing the efficiency with which pyruvic acid can be used in the Krebs cycle. 1

This results in the decrease of lactic acid accumulated in tissues. 1

Along with this increased efficiency, carbon dioxide is eliminated from the body to reduce the chances of its concentration becoming too high. 1

However, in order for people to receive the most benefit and reduce the chances of damaging their bodies, a number of related factors must be considered. For example, it is critical that a proper diet and adequate sleep be maintained. 2

Furthermore, congenital cardiovascular problems may become acute during vigorous exercise. 1

Unless people are aware of how to perform a particular type of strenuous activity properly, serious physical damage may result over an extended priod of time. 1

(e.g., Joggers who run incorrectly may eventually suffer from injured knees, ankles, or backs.)

Possible: 20

Maximum: 15

Quality: 2

Total: 17

Teacher Notes

OAC biology : optional unit II : energy and the living cell